FINAL
UNIFORM FEDERAL POLICY
QUALITY ASSURANCE PROJECT PLAN

EASTERN PLUME – OPERABLE UNIT 1
NEW CASSEL/HICKSVILLE GROUNDWATER CONTAMINATION
SUPERFUND SITE
NASSAU COUNTY, NEW YORK

Revision: 0

Prepared for:
United States Environmental Protection Agency
290 Broadway
New York, New York 10007-1866

U.S. EPA Site Number: NY0001095363

and

101 Frost Street Associates, L.P. and Next Millennium Realty, LLC

Prepared by:
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April 2022

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EXECUTIVE SUMMARY

On behalf of 101 Frost Street Associates, L.P. and Next Millennium Realty LLC, EnSafe Inc. has prepared this Uniform Federal Policy — Quality Assurance Project Plan (UFP-QAPP) to describe the policies and procedures to be utilized during implementation of the Pre-Design Investigation for the Eastern Plume of Operable Unit (OU) 1 of the New Cassel/Hicksville Groundwater Contamination Superfund Site (Site), located in Nassau County, New York. The remedy for OU1 was selected in the OU1 Record of Decision issued by the United States Environmental Protection Agency on September 30, 2013. This UFP-QAPP presents the sampling rationale, design, and quality assurance and quality control procedures to be followed for the duration of this project.

Work performed under this UFP-QAPP include vertical groundwater profile boring and monitoring well installation. At this time, it is understood that U.S. EPA plans to collect groundwater samples from these newly installed monitoring wells and select existing monitoring wells (PDI Directive 1, Round 2). This UFP-QAPP includes analytical information regarding these groundwater samples, but does not specifically identify samples for analyses. Should U.S. EPA designate this work to be performed by the Plume Group Respondents, this UFP-QAPP will be updated where necessary (e.g., wells identified for sampling, analyses, etc.).

Table ES-1. Crosswalk: UFP-QAPP elements and related worksheets and documents.

Optimized Uniform Federal Policy — Quality Assurance Project Plan Worksheets		**2106-G-05 Quality Assurance Project Plan Guidance Section**	
1 and 2	Title and Approval Page	2.2.1	Title, Version, and Approval/Sign-off
3 and 5	Project Organization and Quality Assurance Project Plan (QAPP) Distribution	2.2.3	Distribution List
		2.2.4	Project Organization and Schedule
4, 7, and 8	Personnel Qualifications and Sign-off Sheet	2.2.1	Title, Version, and Approval/Sign-off
		2.2.7	Special Training Requirements and Certification
6	Communication Pathways	2.2.4	Project Organization and Schedule
9	Project Planning Session Summary	2.2.5	Project Background, Overview, and Intended Use of Data
10	Conceptual Site Model	2.2.5	Project Background, Overview, and Intended Use of Data
11	Project/Data Quality Objectives	2.2.6	Data/Project Quality Objectives and Measurement Performance Criteria
12	Measurement Performance Criteria	2.2.6	Data/Project Quality Objectives and Measurement Performance Criteria
13	Secondary Data Uses and Limitations	Chapter 3	QAPP Elements for Evaluating Existing Data

Optimized Uniform Federal Policy — Quality Assurance Project Plan Worksheets		2106-G-05 Quality Assurance Project Plan Guidance Section	
14 and 16	Project Tasks and Schedule	2.2.4	Project Organization and Schedule
15	Project Action Limits and Laboratory-Specific Detection/Quantitation Limits	2.2.6	Data/Project Quality Objectives and Measurement Performance Criteria
17	Sampling Design and Rationale	2.3.1	Sample Collection Procedure, Experimental Design, and Sampling Tasks
18	Sampling Locations and Methods	2.3.1	Sample Collection Procedure, Experimental Design, and Sampling Tasks
		2.3.2	Sampling Procedures and Requirements
19 and 30	Sample Containers, Preservation, and Hold Times	2.3.2	Sampling Procedures and Requirements
20	Field Quality Control	2.3.5	Quality Control Requirements
21	Field Standard Operating Procedure	2.3.2	Sampling Procedures and Requirements
22	Field Equipment Calibration, Maintenance, Testing, and Inspection	2.3.6	Instrument/Equipment Testing, Calibration and Maintenance Requirements, Supplies and Consumables
23	Analytical Standard Operating Procedures	2.3.4	Analytical Methods Requirements and Task Description
24	Analytical Instrument Calibration	2.3.6	Instrument/Equipment Testing, Calibration and Maintenance Requirements, Supplies and Consumables
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection	2.3.6	Instrument/Equipment Testing, Calibration and Maintenance Requirements, Supplies and Consumables
26 and 27	Sample Handling, Custody, and Disposal	2.3.3	Sample Handling, Custody Procedures, and Documentation
28	Analytical Quality Control and Corrective Action	2.3.5	Quality Control Requirements
29	Project Documents and Records	2.2.8	Documentation and Records Requirements
31, 32, and 33	Assessments and Corrective Action	2.4	Assessments and Data Review (check)
		2.5.5	Reports to Management
34	Data Verification and Validation Inputs	2.5.1	Data Verification and Validation Targets and Methods
35	Data Verification Procedures	2.5.1	Data Verification and Validation Targets and Methods
36	Data Validation Procedures	2.5.1	Data Verification and Validation Targets and Methods
37	Data Usability Assessment	2.5.2	Quantitative and Qualitative Evaluations of Usability
		2.5.3	Potential Limitations on Data Interpretation
		2.5.4	Reconciliation with Project Requirements

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FIGURES

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APPENDICES

LIST OF ACRONYMS

µ/L	micrograms per liter
%R	percent recovery
%RPD	percent relative percent difference
Bgs	below ground surface
BS	Bachelor of Science
CAS	Chemical Abstracts Service
CCV	continuing calibration verification
CFR	Code of Federal Regulation
CHMM	Certified Hazardous Material Manager
COC	chemical of concern
COR	Contracting Officer Representative
CSM	Conceptual Site Model
CSO	Corporate Safety Officer
DQO	data quality objectives
FD	field duplicate
FTL	field team leader
GC	gas chromatograph
GC/MS	gas chromatography/mass spectrometry
HAZWOPER	Hazardous Waste Operations and Emergency Response
ICAL	initial calibration
ICP-AES	inductively-coupled plasma/atomic emission spectroscopy
ICV	initial calibration verification
ID	identifier
L	liter
LCS/LCSD	laboratory control sample/laboratory control sample duplicate
MDL	method detection limit
mL	milliliter
MS	Master of Science
MS/MSD	matrix spike/matrix spike duplicate
NA	not applicable
NELAC	National Environmental Laboratory Accreditation
OSHA	Occupational Safety and Health Administration

OU	operable units
PDI	pre-design investigation
PM	project manager
PMP	Project Management Plan
POC	point of contact
PPE	personal projective equipment
PSQ	principal study question
QA	quality assurance
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	quality control
QLs	quantitation limits
RA	remedial action
RD	remedial design
RF	response factors
ROD	Record of Decision
RPD	relative percent difference
RRT	relative retention time
RT	retention time
SI	site inspection
SOP	Standard Operating Procedure
SSO	Site Safety Officer
TB	trip blank
TCL	target cleanup level
UFP-QAPP	Uniform Federal Policy Quality Assurance Project Plan
U.S. EPA	Unites States Environmental Protection Agency
VOC	volatile organic compound

QAPP WORKSHEETS #1 and #2: TITLE AND APPROVAL PAGE

(Uniform Federal Policy Quality Assurance Project Plan [UFP-QAPP] Manual Section 2.1)
(United States Environmental Protection Agency [U.S. EPA] 2106-G-05 Section 2.2.1)

1. Project Identifying Information

   a. Site Name/Project Name: New Cassel/Hicksville Groundwater Contamination Superfund Site – Eastern Plume
   b. Site Location/Number: Nassau County, New York
   c. Contract/Work Assignment Number: 0888820265-005

2. Lead Organization – Eastern Plume: EnSafe Inc.

Mrs. Alexandra Stark, Project Manager	Date
Mrs. Tina Clemmey, Quality Assurance Manager/Project Chemist	Date

3. Federal Regulatory Agency: U.S. EPA Region 2

Julio Vasquez, Remedial Project Manager	Date

4. State Regulatory Agency: New York Department of Environmental Conservation

Kerry Maloney, Remedial Project Manager	Date

5. Other Stakeholders: 101 Frost Street Associates, L.P. and Next Millennium Realty LLC

_____ _____

Ted Pupilla, Authorized Representative Date

6. Plans and reports from previous investigations relevant to this project:

EnSafe Inc. *Emergency Response Plan – Eastern Plume, New Cassel/Hicksville Groundwater Contamination Superfund Site. Nassau County, New York.* April 2022.

- *Field Sampling Plan – Eastern Plume, New Cassel/Hicksville Groundwater Contamination Superfund Site. Nassau County, New York.* April 2022.

- *Health and Safety Plan – Eastern Plume, New Cassel/Hicksville Groundwater Contamination Superfund Site. Nassau County, New York.* April 2022.

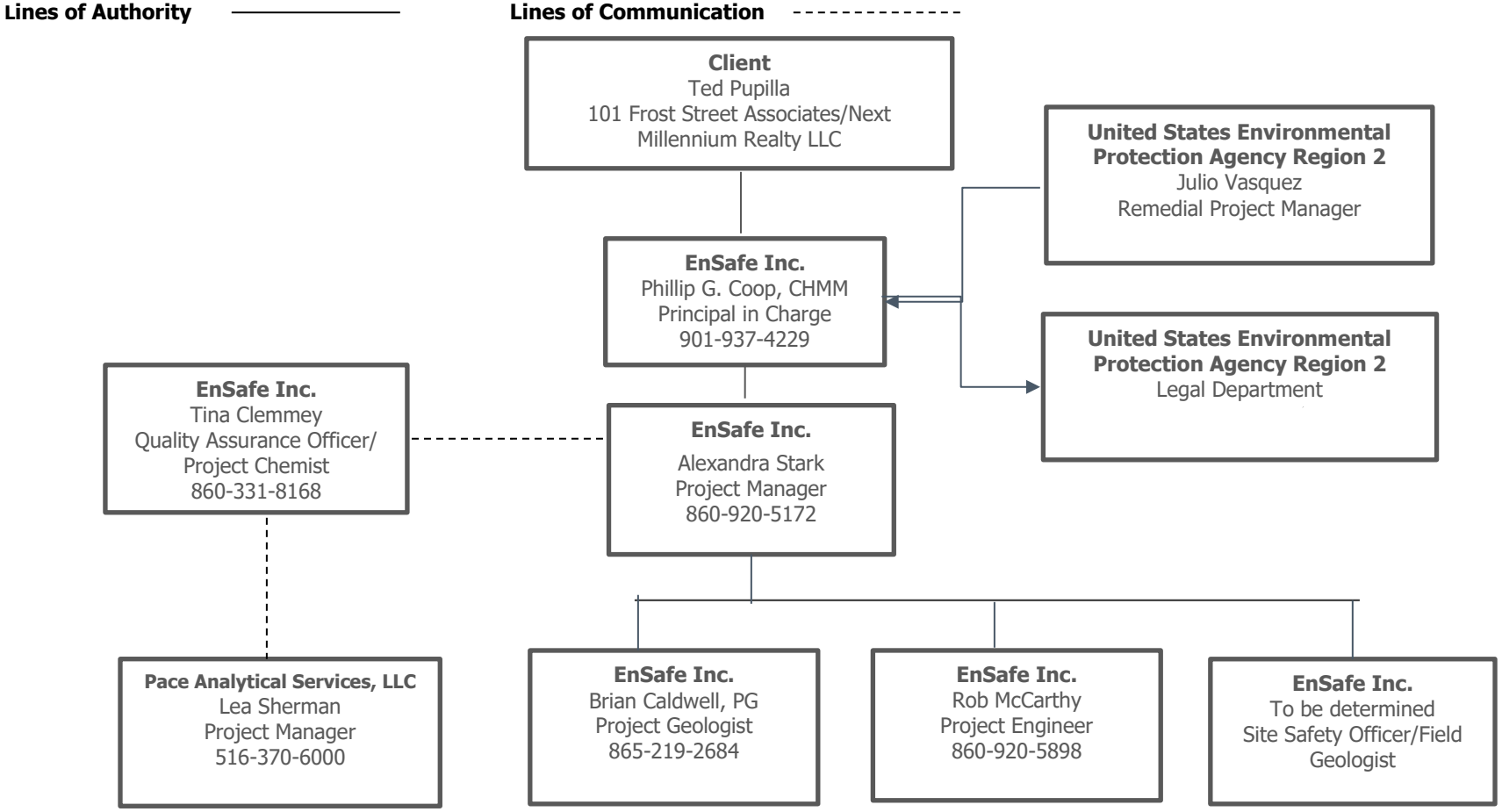
- *Site Management Plan – Eastern Plume, New Cassel/Hicksville Groundwater Contamination Superfund Site. Nassau County, New York.* April 2022.

United States Environmental Protection Agency. *Record of Decision, Operable Unit 1, New Cassel/Hicksville Ground Water Contamination Superfund Site, Towns of North Hempstead, Hempstead and Oyster Bay, Nassau County New York*. September 2013.

- *New Cassel/Hicksville Groundwater Contamination Site, OU1 RD Pre-Design Work Plan*. May 2017.

QAPP WORKSHEETS #3 and #5: PROJECT ORGANIZATIONAL CHART AND QAPP DISTRIBUTION

(UFP-QAPP Manual Section 2.3 and 2.4)



QAPP WORKSHEETS #4, #7, and #8: PERSONNEL QUALIFICATIONS AND SIGN-OFF SHEET

(UFP-QAPP Manual Sections 2.3.2 — 2.3.4)

Key project personnel for each organization performing tasks are listed below. Copies of training/certifications are provided in Appendix A.

Organization: EnSafe Inc. (Eastern Plume Prime Contractor)

Name	Project Title/Role	Education/Experience	Specialized Training/Certifications	Signature/Date
Alexandra Stark	Project Manager (PM)	• Bachelor of Science (BS), Civil Engineer, Northeastern University • 12 years of experience in environmental consulting including Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site investigations, site remediation, and site management.	• Professional Engineer: New York, Connecticut, Rhode Island, Massachusetts • HAZWOPER 40-hour • HAZWOPER 8-hour refresher • First Aid/CPR	
Tina Clemmey	Quality Assurance Officer/ Project Chemist/Data Validator	• BS, Biochemistry, Suffolk University • 28 years in environmental consulting including RCRA and CERCLA site investigations, site remediation, and data validation.	• HAZWOPER 40-hour • HAZWOPER 8-hour refresher • First Aid/CPR	
Brian Caldwell	Project Geologist	• BS, Geology, Florida State University • MS, Geology, Florida State University • 33 years in environmental consulting as a hydrogeologist including RCRA and CERCLA site investigations, site modeling, site remediation, and site management.	• Professional Geologist; New York (511), Tennessee, Florida, Virginia, Pennsylvania • Certified Professional Geologist: Nationwide (09381) • HAZWOPER 40-hour • HAZWOPER 8-hour refresher • First Aid/CPR	
Rob McCarthy	Project Engineer	• BS, Civil Engineering, University of Florida • MS, Civil Engineering, University of Florida • 26 years of experience in environmental consulting including RCRA and CERCLA site investigations, site remediation, and site management.	• Professional Engineer: New York (082259), Connecticut, Rhode Island, Kansas • HAZWOPER 40-hour • HAZWOPER 8-hour refresher • First Aid/CPR	
To be determined	Field Team Leader; Site Safety Officer	• To be determined	• HAZWOPER 40-hour • HAZWOPER 8-hour refresher • First Aid/CPR	

Organization: Pace Analytical Services LLC

Name	Project Title/Role	Education/Experience	Specialized Training/Certifications	Signature/Date
Lea Sherman	Laboratory Project Manager	• Bachelor of Arts, Environmental Studies, State University of New York at Buffalo	• NA	

QAPP WORKSHEET #6: COMMUNICATION PATHWAYS

(UFP-QAPP Manual Section 2.4.2)

The communication drivers for the Eastern Plume – Operable Unit 1 New Cassel/Hicksville Groundwater Contamination Superfund Site QAPP are shown below. The Organizations listed below will be provided the most current approved version of the QAPP.

Communication Driver	Organization	Name	Contact Information	Procedure (timing, pathway to/from, etc.)
Regulatory Agency Interface	U.S. EPA Region 2 RPM	Julio Vasquez	212-637-4323	The U.S. EPA RPM will inform the U.S. EPA Superfund Division Chief of work progress on a periodic basis.
Field Progress Reports	EnSafe Inc. (EnSafe) FTL/SSO EnSafe PM	TBD Alexandra Stark	TBD 860-920-5172	The EnSafe FTL will contact the EnSafe PM daily via phone message summarizing the field progress. The EnSafe PM will contact the Stakeholders every 1 to 2 days either by phone message and/or email summarizing field progress.
Gaining Site Access	EnSafe Inc PM	Alexandra Stark	860-920-5172	The EnSafe PM will contact the Site representative verbally or via email at least 3 days prior to commencement of field work to arrange for access to the Site for all field personnel.
Stop Work due to Safety Issues	EnSafe FTL/SSO EnSafe PM	TBD Alexandra Stark	TBD 860-920-5172	Any field team member who observes an unsafe situation has the authority to stop work. The responsible party verbally informs the EnSafe PM within 1 hour of recommendation to stop work and within 24 hours of recommendation to restart work.
QAPP Changes prior to Field/ Laboratory work	EnSafe PM U.S. EPA Region 2 RPM Authorized Representative	Alexandra Stark Julio Vasquez Ted Pupilla	860-920-5172 212-637-4323 516-375-6039	The EnSafe PM is responsible for initiating any QAPP change request. Any changes of the approved QAPP will be made only upon written authorization. These changes will be provided to the project team after final approval, ensuring that the most current approved version of the QAPP is available, distributed, and implemented.
Field Corrective Actions	EnSafe FTL/SSO EnSafe PM	TBD Alexandra Stark	TBD 860-920-5172	The EnSafe FTL informs the EnSafe PM verbally within same day when field corrective actions are needed; the EnSafe PM informs the Stakeholders via email within 24 hours that corrective actions have been implemented. Corrective actions will be documented in weekly progress reports. Significant corrective actions will be verbally communicated to the Stakeholders.

Communication Driver	Organization	Name	Contact Information	Procedure (timing, pathway to/from, etc.)
QAPP Changes in the Field	EnSafe FTL/SSO EnSafe PM	TBD Alexandra Stark	TBD 860-920-5172	The EnSafe FTL will inform the EnSafe PM verbally within same day of the need for a QAPP change in the field. The EnSafe PM will inform the Stakeholders by email within 24 hours. The EnSafe PM will send a concurrence letter, if warranted, within 2 calendar days and the Stakeholders will sign the letter within 5 business days of receipt. Any scope changes of the approved QAPP will be made only upon written authorization. These changes will be provided to the project team after final approval, ensuring that the most current approved version of the QAPP is available, distributed, and implemented.
Recommendations to stop work stop work if QAPP is not being followed properly and initiate work upon corrective action	EnSafe FTL/SSO EnSafe PM EnSafe QAO	TBD Alexandra Stark Tina Clemmey	636-399-6787 860-920-5172 860-331-8168	The responsible party verbally informs the EnSafe PM and FTL within 1 hour of recommendation to stop work and within 24 hours of recommendation to restart work. Responsible party follows verbal notification with an email to the Project Team within 24 hours. Significant corrective actions will be verbally communicated to the Stakeholders.
Sample Receipt and Laboratory Quality Variances	Pace Analytical Services LLC PM EnSafe Chemist EnSafe FTL/SSO EnSafe PM	Lea Sherman Tina Clemmey TBD Alexandra Stark	860-999-3563 860-331-8168 TBD 860-920-5172	The laboratory PM will notify (verbally or via email) the EnSafe Chemist immediately upon receipt of any chain of custody/sample receipt variances for clarification or direction from the EnSafe FTL. The EnSafe Chemist will notify (verbally or via email) the laboratory PM and the EnSafe FTL within 1 business day of any required corrective action. The EnSafe Chemist will notify (verbally or via email) the EnSafe PM within 1 business day of any required corrective action.
Analytical Corrective Actions	Pace Analytical Services LLC PM EnSafe Chemist	Lea Sherman Tina Clemmey	860-999-3563 860-331-8168	The laboratory PM shall notify the EnSafe Chemist of any analytical data anomaly within 1 business day of discovery. After the laboratory receives guidance from the EnSafe Chemist, the laboratory will initiate any corrective action to prevent further anomalies.
Analytical Data Quality Issues	Pace Analytical Services LLC PM EnSafe Chemist EnSafe PM	Lea Sherman Tina Clemmey Alexandra Stark	860-999-3563 860-331-8168 860-920-5172	The laboratory PM notifies (verbally or via email) the EnSafe Chemist within 1 business day of when an issue related to laboratory data are discovered. The EnSafe Chemist will notify the EnSafe PM within 1 business day. The EnSafe Chemist will notify the EnSafe PM (verbally or via email) within 48 hours of validation completion that a non-routine and significant laboratory quality deficiency has been detected that could affect this project. The EnSafe PM will verbally advise the Stakeholders within 24 hours of notification from the chemist with recommendations for corrective actions.

Communication Driver	Organization	Name	Contact Information	Procedure (timing, pathway to/from, etc.)
Reporting Data Validation Issues/Data Validation Corrective Actions	EnSafe Validator EnSafe PM	Tina Clemmey Alexandra Stark	860-331-8168 860-920-5172	The EnSafe Validator will perform validation as specified in Worksheets #34, #35, and #36, and will contact the laboratory as soon as possible if issues are found that require corrective action. If the EnSafe Validator identifies data with serious deficiencies during the data validation process that requires corrective action, the EnSafe PM will coordinate with the validator to take corrective action appropriate for the identified deficiency to ensure the project objectives are met. Corrective action may include resampling and/or reanalyzing the affected samples, as determined by the EnSafe PM and Stakeholders.
Notification of Data with Serious Deficiencies	Pace Analytical Services LLC PM EnSafe Chemist EnSafe PM	Lea Sherman Tina Clemmey Alexandra Stark	860-999-3563 860-331-8168 860-920-5172	If the laboratory determines that they have generated data with serious deficiencies, the laboratory PM will notify (verbally or via email) the EnSafe Chemist within 1 business day of when the issue is discovered. The EnSafe Chemist will notify (verbally or via email) ENSAFE PM within 1 business day of the need for corrective action, if the data constitute a significant issue (i.e., critical sample data). Corrective action may include resampling and/or reanalyzing the effected samples. The EnSafe PM will take corrective action appropriate for the identified deficiency to ensure the project objectives are met. The EnSafe PM will notify (verbally or via email) the Stakeholders on any problems with the laboratory or analysis that could significantly affect the usability of the data or project failures that impact the ability to complete the scope of work.

Notes:

TBD = to be determined
U.S. EPA = U.S. Environmental Protection Agency
RPM = Remedial Project Manager
FTL = Field Team Leader
SSO = Site Safety Officer
PM = Project Manager
CSO = Corporate Safety Officer
QAPP = Quality Assurance Project Plan
QAO = Quality Assurance Officer
QAM = Quality Assurance Manager

QAPP WORKSHEET #9: PROJECT PLANNING SESSION SUMMARY

(UFP-QAPP Manual Section 2.5.1)

A project planning session has not been conducted at the time this UFP-QAPP was written. Planning sessions are required prior to the start of work to finalize details such as final boring and monitoring well locations, targeted monitoring wells for sample collection, responsible party for PDI Directive 1, Round 2, etc.

Future project planning sessions will be documented in this worksheet, whether sessions are internal (project teams only) or external (includes regulators and/or stakeholders). Each summary will provide a concise record of participants, key decisions or agreements reached, and action items. Depending on the stage of planning, project-planning sessions should involve key technical personnel as needed. Scoping sessions can be by phone, web-conferencing, and/or face-to-face meeting depending upon logistical considerations. Previous meeting minutes can be included as attachments if necessary and referenced. Users may find it helpful to have copies of worksheets on hand for all planning sessions, in whatever state of completion they may be. The following template may be modified to suit both the project and the specific planning session.

Date of planning session:
Location:
Purpose:
Participants:

Notes/Comments:
Consensus decisions made:
Action Items:

QAPP WORKSHEET #10: CONCEPTUAL SITE MODEL

(UFP-QAPP Manual Section 2.5.2)

10.1 Introduction

The Site conceptual model is described in the OU1 Record of Decision (ROD) (Section 5.9, 6.1, and 6.2). Human receptors at OU1 include municipal users of drinking water. No vapor, ecological, or soil receptors have been identified.

10.2 Site Description

The Site comprises a widespread area of groundwater contamination within the Town of North Hempstead, Town of Hempstead, and the Town of Oyster Bay, all of which are located in Nassau County, New York (Figure 10-1). The Site is approximately 6.5 square miles. The Site was listed on the National Priorities List in 2011.

The Site's Operable Unit (OU) 1 is a discrete portion of contaminated groundwater downgradient of the New Cassel Industrial Area (NCIA) located within the Towns of North Hempstead and Hempstead. OU1 is located primarily in Salisbury, an unincorporated area of the Town of Hempstead; and the portion of OU1 north of Grand Boulevard is located within the Hamlet of New Cassel, in the Town of North Hempstead (Figure 10-2). OU1 is approximately 211 acres and consists of residential properties, as well as some commercial areas.

Upgradient of OU1 is the NCIA, which is currently being managed by the New York State Department of Environmental Conservation. The NCIA encompasses approximately 170 acres and is bounded by the Long Island Railroad to the north, Frost Street to the east, Old Country Road to the south, and Grand Boulevard to the southwest.

The Town of Hempstead's Bowling Green Water District operates Wells 1 and 2 on property that is located within OU1 (labeled as Hempstead-Bowling Green Wells 1 and 2, on Figure 10-2). The Bowling Green Water District has been treating groundwater pumped from these two wells since 1990 when a granular activated carbon system was installed. Five years later, the treatment system was supplemented with an air stripper. The treatment system is still in operation. The Town of Hempstead continues to maintain monitoring and treatment activities to address volatile organic compound (VOC) contamination prior to its distribution to the drinking water system.

10.3 Site Geology/Hydrogeology

The principal hydrogeologic units underlying OU1 are the glacial outwash and morainal deposits known as the Upper Glacial Aquifer (UGA) and the underlying Magothy Formation and Matawan Group (Magothy). Beneath these two units are the clay member and the Lloyd Sand member of the Raritan Formation.

The UGA is estimated to be 60 to 80 feet thick and consists predominantly of coarse-grained sands and gravels. A distinct transition between the UGA and the Magothy units has not been observed in the OU1 area. The underlying Magothy Formation sediments (estimated to be approximately 600 feet thick) are characterized by sand and silty sand with discontinuous clay and silt layers. Geologic studies in the area have revealed that sediments tend to become finer in size fraction downward in the Magothy Formation, except within the basal portion where coarse-grained sands and gravels are prevalent.

Unconfined groundwater is generally found at the Site between 38 to 50 feet below ground surface (bgs). Groundwater within the UGA and Magothy aquifers flows in a south-southwest direction in the area downgradient of the NCIA. There is a natural downward vertical gradient across OU1 that is enhanced by the pumping of the Bowling Green Water District supply wells. Pumping of the Bowling Green Water District water supply wells also may influence the groundwater flow direction above the depth of their production interval, which is approximately 470 to 580 feet bgs.

10.4 Nature of Groundwater Contamination

The Site has been characterized by VOC-contaminated groundwater that has impacted several water supply wells, including four Town of Hempstead municipal wells, six Hicksville water supply wells, and one Village of Westbury water supply well. Analytical results of groundwater samples from the Site have revealed three groundwater plumes with concentrations of VOCs in excess of the U.S. EPA's promulgated health-based protective maximum contaminant levels and New York State's standards. OU1 has three plumes, the Western Plume, the Central Plume, and the Eastern Plume, each with different source areas and contamination chemical compositions.

At the time of data collection for the OU1 ROD (2011), the Eastern Plume, was comprised predominantly of tetrachloroethene up to 16,000 micrograms per liter (µg/L) with some trichloroethene and concentrations less than 23 µg/L of 1,1,1-trichloroethane. Contamination appears to migrate deeper as the distance along the plume axis increases away from the NCIA. Subsequent groundwater sampling events since 2011 indicate the Eastern Plume groundwater

concentrations have decreased at all OU1 wells except MW-17D, located in the southern portion of OU1.

10.5 Contaminants of Concern

Contaminants of concern for the Site and their associated action levels are presented in Table 10-1.

Table 10-1
Contaminants of Concern

Contaminant	NYSDEC Water Quality Standards (µg/L)	U.S. EPA Maximum Contaminant Level (µg/L)	Selected Criteria (µg/L)
Dichlorodifluoromethane	5	NS	5
Chloromethane	NS	NS	NS
Vinyl chloride	2	2	2
Bromomethane	5	NS	5
Chloroethane	5	NS	5
Trichlorofluoromethane	5	NS	5
1,1-Dichloroethene	5	7	5
1,1,2-Trichloro-1,2,2-trifluoroethane	5	NS	5
Acetone	NS	NS	NS
Carbon disulfide	60	NS	60
Methyl acetate	NS	NS	NS
Methylene chloride	5	5	5
trans-1,2-Dichloroethene	5	100	5
Methyl tert-butyl ether	NS	NS	NS
1,1-Dichloroethane	5	NS	5
cis-1,2-Dichloroethene	5	70	5
2-Butanone (MEK)	NS	NS	NS
Chloroform	7	80	7
1,1,1-Trichloroethane	5	200	5
Cyclohexane	NS	NS	NS
Carbon tetrachloride	5	5	5
Benzene	1	5	1
1,2-Dichloroethane	0.6	5	0.6
Trichloroethene	5	5	5
Methylcyclohexane	NS	NS	NS
Bromodichloromethane	5	80	5
1,2-Dichloropropane	1	5	1
Toluene	5	1000	5
trans-1,3-Dichloropropene	0.4	NS	0.4
cis-1,3-Dichloropropene	NS	NS	NS
4-Methyl-2-pentanone	NS	NS	NS
1,1,2-Trichloroethane	1	5	1
Tetrachloroethene	5	5	5
2-Hexanone	NS	NS	NS
Dibromochloromethane	NS	80	80

Table 10-1
Contaminants of Concern

Contaminant	NYSDEC Water Quality Standards (µg/L)	U.S. EPA Maximum Contaminant Level (µg/L)	Selected Criteria (µg/L)
1,2-Dibromoethane	NS	500	500
Chlorobenzene	5	100	5
Ethylbenzene	5	700	5
Xylenes (total)	5	NS	5
Styrene	5	100	5
Bromoform	NS	80	80
Isopropylbenzene	5	NS	5
1,1,2,2-Tetrachloroethane	5	NS	5
1,3-Dichlorobenzene	5	NS	5
1,4-Dichlorobenzene	5	75	5
1,2-Dichlorobenzene	5	600	5
1,2-Dibromo-3-chloropropane	0.04	20	0.04
1,2,4-Trichlorobenzene	5	70	5
1,4-Dioxane	NS	NS	NS

Notes:
NYSDEC = New York State Department of Environmental Conservation
U.S. EPA = United States Environmental Protection Agency
VOC = volatile organic compound
µg/L = micrograms per liter

10.6 Additional Analytes

Per the PDI Work Plan (U.S. EPA, May 2017), a minimum of 30% of the groundwater samples collected from permanent monitoring wells will also be analyzed for ferrous iron (Standard Method [SM]3500-Fe D), dissolved and total metals (U.S. EPA Method 6010), total hardness (SM2340B), and alkalinity (test kit or SM2320B) to support pilot testing. The Target Analyte List for metals includes: aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, potassium, selenium, silver, sodium, strontium, thallium, tin, vanadium, and zinc.

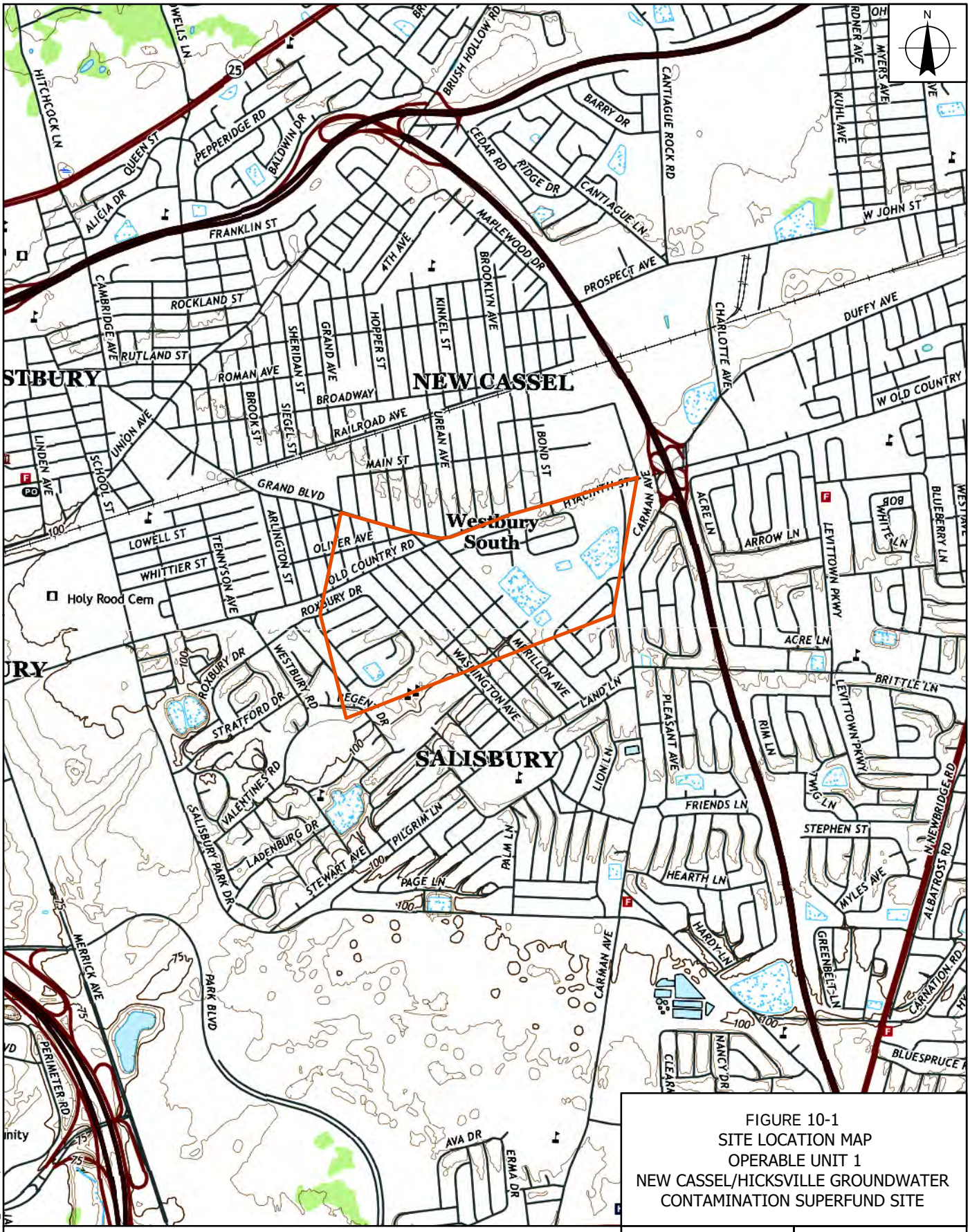


FIGURE 10-1
SITE LOCATION MAP
OPERABLE UNIT 1
NEW CASSEL/HICKSVILLE GROUNDWATER
CONTAMINATION SUPERFUND SITE

LEGEND

OPERABLE UNIT 1 OF NEW CASSEL/HICKSVILLE GROUNDWATER CONTAMINATION SUPERFUND SITE

NAD 1983 STATE PLANE
NEW YORK ISLAND FEET

0 1,000 2,000

SCALE IN FEET

REQUESTED BY:	AS
DRAWN BY:	MS
DATE:	3/11/2021
PROJECT:	0888820265

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Source: U.S. Geological Survey. Freeport & Hicksville Quadrangles, New York [Map]. Photorevised 2019. 1:24,000. 7.5 Minute Series.

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FIGURE 10-2
SITE MAP
OPERABLE UNIT 1
NEW CASSEL/HICKSVILLE GROUNDWATER
CONTAMINATION SUPERFUND SITE

LEGEND

- HEMPSTEAD-BOWLING GREEN WELLS 1 AND 2
- OPERABLE UNIT 1 OF NEW CASSEL/HICKSVILLE GROUNDWATER CONTAMINATION SUPERFUND SITE

NAD 1983 STATE PLANE
NEW YORK ISLAND FEET

0 350 700

SCALE IN FEET

REQUESTED BY:	AS
DRAWN BY:	MS
DATE:	3/15/2021
PROJECT:	0888820265

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Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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QAPP WORKSHEET #11: PROJECT/DATA QUALITY OBJECTIVES

(UFP-QAPP Manual Section 2.6.1)

11.1 Problem Definition (Data Quality Objective Step 1)

Data are needed to enhance the current understanding of the nature and extent of VOC contamination and to assess whether elevated levels of constituents are indicative of releases from former operations at OU1. Data and other information obtained during the pre-design investigation (PDI) will be used to address data gaps prior to the generation of the remedial design (RD)/remedial action (RA).

Problem statements are listed below.

- To determine horizontal and vertical extent of Eastern Plume groundwater contamination (greater than 20 µg/L total VOCs) previously encountered during the remedial investigation.

- To collect sufficient data to support the Eastern Plume RD/RA, which will remediate groundwater contamination above the ROD action level (100 µg/L total VOCs).

11.2 Goals of the Study (Data Quality Objective Step 2)

The overall quality assurance (QA) objective for this project is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and reporting that will provide results that are scientifically valid at levels that are sufficient to meet data quality objectives (DQOs). Specific procedures for sampling, chain-of-custody, laboratory instrument calibration, laboratory analysis, reporting of data, internal quality control (QC), preventive maintenance of field equipment, and corrective action are described in other sections of this QAPP.

In combination, QA/QC represents a set of procedures designed to produce analytical data of known and measurable quality. A useful distinction between QA and QC can be made as follows:

- QC represents the set of measurement procedures (spikes, blanks, replicates, calibration, etc.), used to provide overall evidence of the quality of a particular analytical batch;

- QA represents the set of procedures used to ensure that this evidence is available and used properly to evaluate and, if necessary, to qualify the data quality. The following sections describe the DQO process for the PDI.

The purpose of DQO Step 2 is to define the principal study questions (PSQs) that need to be resolved to address the problems identified in DQO Step 1 and identify the alternative actions that would result from resolution of the PSQs. The PSQ and alternative actions are combined into decision statements that express a choice among alternative actions.

PSQs were developed for human exposure to define decision statements that link the PSQ to possible or potential actions that will resolve the problem. Table 11-1 provides the PSQs of equal priority, potential alternative actions, and resulting decision statements for each question.

Table 11-1
Principal Study Questions, Alternative Actions, and Decision Statements

No.	Principal Study Questions	Alternative Action
1.	Has the horizontal and vertical extent of Eastern Plume groundwater contamination (greater than 20 µg/L total VOCs) been delineated?	a. No — Follow-up action may be warranted. Possible follow-up actions include expanded investigation. b. Yes — No additional characterization required. Proceed to next steps of the RD/RA (PSQ 2).
Decision Statement: Determine whether the vertical and lateral extent of Eastern Plume groundwater contamination containing constituents at concentrations that exceed the U.S. EPA OU1 ROD action level has been delineated to decide whether or not further Site characterization is needed.		
2.	Has sufficient data been collected to begin the RD/RA?	a. No — Follow-up action may be warranted. Possible follow-up actions include expanded investigation. b. Yes — No additional characterization required. Proceed to next steps of the RD/RA.
Decision Statement: Determine whether the sufficient data has been collected to perform the RD/RA and decide whether or not further Site characterization is needed.		

Notes:
U.S. EPA = United States Environmental Protection Agency
OU = operable unit
ROD = Record of Decision
µg/L = micrograms per liter
VOC = volatile organic compound
RD = remedial design
RA = remedial action
PSQ = principal study question

11.3 What Type of Data are Needed?

The PDI will evaluate the Eastern plume for VOCs to direct subsequent RD/RA activities. Geochemical analytes are considered ancillary parameters and are not used to evaluate project DQOs. Specific informational inputs will serve as the basis for decisions during the execution of this project:

- **Chemical data:** Groundwater data will be collected to determine if chemicals of concern (COCs) are present and assess potential threats to human health and the environmental at

OU1. Detected COCs will be compared to their respective action levels. Analytes are identified on Worksheet #15.

- **Chemical data:** Groundwater data will also be collected to determine the concentration of additional analytes (Section 10.6) to facilitate RD/RA.

- **Field Measurements**: Field parameters, including pH, temperature, specific conductivity, oxidation-reduction potential, dissolved oxygen, and turbidity, will be used to confirm groundwater samples are representative of the formation being investigated.

- **Water level measurements:** Prior to sampling, the depth to the static water level will be measured in all wells using an electronic water level meter. The depth will be measured in units of feet (to the nearest 0.01 foot) with respect to the top of the well casing to determine the depth-to-water bgs. Water levels will be recorded on a water level measurement form. The water level meter will be decontaminated prior to use and between each monitoring well.

- **Action Levels:** The action levels include the following:

  — Groundwater screening criteria
    - U.S. EPA Safe Drinking Water Maximum Contaminant Levels
    - New York State Department of Environmental Conservation Water Quality Standards

Every effort was made to select a laboratory able to achieve quantitation limits (QLs) that are low enough to measure constituent concentrations less than the action levels identified in Worksheet #15. However, in some cases, current technology used by the analytical methods cannot achieve all of the action levels. Also, it should be noted that the laboratory's method detection limits (MDLs) listed in Worksheet #15 are targets that are achievable under *optimal conditions*. Physical characteristics such as moisture content will affect the actual detection limit achieved. In addition, samples may contain constituents that cause or contribute to analytical interferences, which may yield elevated detection limits. The MDL is defined as the minimum concentration of a substance (analyte) that can be measured and reported with 99% confidence that the analyte concentration is greater than zero in a given matrix. MDLs are developed by the laboratory annually. QLs are generally the lowest standard of the calibration that will be reported for undetected values; however, if detected, values will be reported down to laboratory MDLs. Therefore, MDLs will be used to assess whether analytical performance can meet action levels used to resolve decision statements.

11.4 Analytic Approach (Data Quality Objective Step 3)

The purpose of this step is to identify the informational inputs (data) that will be required to resolve the decisions identified in Step 2. Human receptors are principally users of municipal drinking water supplies, some of which use groundwater within OU1 as a groundwater source with wellhead treatment. Data collected during the PDI and consideration of land use, receptors, and groundwater use will be used to resolve the decisions.

11.5 Study Boundaries (Data Quality Objective Step 4)

The objective of DQO Step 4 is to define the spatial and temporal boundaries of the problem to be addressed. This involves first identifying the target population from which samples will be collected. The spatial boundaries define the physical area to be studied and the locations where samples should be taken. The temporal boundaries describe the time frame the study data will represent and when the samples should be taken. Implementing this step ensures that the sampling design will result in the collection of data that accurately reflects the true condition of the site under investigation. Practical constraints that could interfere with sampling are also identified.

Population of Interest

Prior to defining the spatial and temporal boundaries of the Site under investigation, it is first necessary to clearly define the populations of interest that apply for each decision statement. The term "population" refers to the total collection or universe of objects, contaminated media, or people to be studied, from which samples will be drawn. VOCs in groundwater constitute the population of interest for this PDI for the decision statements listed earlier in Table 1-3.

Spatial/Geographic Boundaries

Figure 4 identifies the geographic boundaries of the study area that apply to each decision statement. Limiting the geographical boundaries of the study area ensures that the investigation does not expand beyond the original scope of the task.

Temporal Boundaries

While the sample collection time frame for resolving decision statements will be governed by project scope, schedule, and stakeholders approval, it is anticipated that sampling will occur in late 2021.

Scale of Decision Making

The scale of decision making refers to the smallest, most appropriate subsets of the population for which decisions will be made based on the temporal or spatial boundaries. To resolve

decision statements, a biased investigation strategy has been developed which employ findings of the phased approach to direct PDI sampling activities.

Practical Constraints on Data Collection

This section contains practical constraints that may impact data collection such as physical barriers, difficult sample matrices, or other conditions that must be considered in the design and scheduling of the sampling program. Potential constraints that could interfere with the PDI data collection are listed below:

- Coordinating access to properties or authorization to work in right-of-ways may affect the project schedule.
- Coordination of activities could affect access to the Site or the project schedule.

11.6 Performance or Acceptance Criteria

The objective of this section is to complete the following:

- Identify potential sources of study error (e.g., field error, analytical error);
- Establish and identify the methods used to reduce potential sources of error; and
- Determine how decision errors will be managed during the project.

Sources of Error

Sources of error may be divided into two main categories: sampling errors and measurement errors. A sampling error occurs when the sampling design, planning, and implementation do not provide for a representative range of heterogeneity at the site. A measurement error occurs because of performance variance from laboratory instrumentation, analytical methods, or operator error. The U.S. EPA identifies the combination of all these errors as a "total study error" (U.S. EPA 2006). One objective of the investigation is to reduce the "total study error" so that decision-makers can be confident that the data collected accurately represent the chemical characteristics of the Site.

Managing Decision Errors

Utilize decision error-minimization techniques in sampling design, sampling methodologies, and laboratory measurement of COCs. Possible decision errors will be minimized during the groundwater sampling by using the following methods:

- Standard field sampling methodologies (as discussed in Worksheets #18 and #21);

- Applicable analytical methods and standard operating procedures (SOPs) for sample analysis by a competent analytical laboratory having appropriate National Environmental Laboratory Accreditation Program accreditation; and

- Confirmation of analytical data to identify and control potential laboratory error and sampling error by using matrix spikes (MS), blanks, and duplicate samples.

Field Data Logs

sample information will be transcribed into a field logbook and/or onto field datasheets.

Analytical Laboratory Sample Management

The sample matrix, number of samples, and number and type of laboratory quality assurance (QA)/quality control (QC) samples are summarized in Worksheets #18 and #20. Worksheets #19 and #30 provide details on the analytical groups, sample volumes, sample container specifications, preservation requirements, and maximum and holding times. The laboratory will provide electronic data deliverable files, portable document format files of the data deliverables for all project data, and a hard copy of data deliverables for all results. Designated samples will be used to obtain necessary subsamples for laboratory QC measurements (e.g., analytical sample duplicate and sample matrix spike/matrix spike duplicate [MS/MSD]). Tasks will be completed using the laboratory SOPs.

EnSafe will provide data validation services and verify and evaluate the usability of the data as described in Worksheets #34 through #36.

11.7 Who Will Collect and Generate the Data?

The PDI was developed to optimize resources and generate data to satisfy the project objectives and goals. The critical objective is to obtain a quality dataset. The sampling design, rationale, and locations are summarized in Worksheets #17 and #18. These worksheets identify where groundwater samples will be collected and the analyses to be conducted for each sample. Worksheets #19, #20, #24–28, and #30 specify analysis design requirements. Environmental samples will be collected by the EnSafe field sampling team personnel. Laboratory analytical data will be generated by Pace Analytical Services, LLC in Melville, New York, accredited by the National Environmental Laboratory Accreditation Program; a copy of the certificate is provided in Appendix B. Specific sample preparation and analytical procedures to be used are provided in Appendix C.

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QAPP WORKSHEET #12: MEASUREMENT PERFORMANCE CRITERIA

(UFP-QAPP Manual Section 2.62)

Measurement Performance Criteria Table Field Quality Control Samples				
QC Sample	**Analytical Group[1]**	**Frequency**	**Data Quality Indicators**	**Measurement Performance Criteria**
Trip Blank	VOCs	One per cooler	Bias/Contamination	No analytes ≥ ½ LOQ, except common lab contaminants, which must be < LOQ
Field Duplicates	VOCs 1,4-dioxane Metals[2] Other[2]	One per analytical group per 20 field samples And at least one collected per week	Precision	RPD must be ≤30% (aqueous)
Equipment Rinsate Blank	VOCs 1,4-dioxane Metals[2] Other[2]	One per analytical group per 20 field samples per equipment type And at least one collected per week	Bias/Contamination	No analytes ≥ ½ LOQ, except common lab contaminants, which must be < LOQ
Matrix Spike/Matrix Spike Duplicate	VOCs 1,4-dioxane Metals[2] Other[2]	One per analytical group per 20 field samples And at least one collected per week	Accuracy/Bias/ Precision	Percent recoveries RPD must be ≤20 (aqueous)
Cooler Temperature Indicator	VOCs 1,4-dioxane Metals[2] Other[2]	One per cooler	Representativeness	Temperature must be above freezing and < or equal to 6 degrees Celsius

Notes:

[1] See Worksheet #15 for full list of analytes.
[2] QA samples of samples collected from permanent monitoring wells will also include these analyses.

QC = quality control
VOCs = volatile organic compounds
≥ = greater than or equal to
< = less than
LOQ = limit of quantitation
RPD = relative percent difference

QAPP WORKSHEET #13: SECONDARY DATA USES AND LIMITATIONS

(UFP-QAPP Manual Section 2.7)

Secondary Data Type	Source	Data Uses Relative to Current Project	Factors Affecting the Reliability of Data and Limitations on Data Use
Report	Record of Decision, Operable Unit 1, September 2013	Establish remedial action objectives and remedy	No limitations

QAPP WORKSHEETS #14 and #16: FIELD PROJECT TASKS AND SCHEDULE

(UFP-QAPP Manual Section 2.8.2)

	Activity	Responsible Party	Planned Start Date	Duration	Planned Completion Date	Deliverable	Deliverable Due Date
Vertical Profile Boring and Monitoring Well Installation	Mobilization	EnSafe	April 18, 2022	1 day	April 19, 2022	Field Notes	Daily
	Vertical Profile Boring Installation and Groundwater Sample Collection	EnSafe	April 20, 2022	17 weeks	August 17, 2022	Field Notes	Daily
	Monitoring Well Installation	EnSafe				Field Notes	Daily
	Laboratory Analysis	Pace				Laboratory reports and data packages	Upon receipt to facilitate well design
	Data Validation	EnSafe	April 20, 2022	Ongoing during field work plus 4 weeks	September 14, 2022	Data validation summary reports	November 18, 2022
	Data Summarization	EnSafe				Data tables	November 18, 2022
	Data Usability Assessment	EnSafe				Data usability summary report	November 18, 2022
	Final Reporting	EnSafe	August 17, 2022	3 months after field work completion	November 18, 2022	PDI Directive 2 Technical Memorandum	November 18, 2022

	Activity	Responsible Party	Planned Start Date	Duration	Planned Completion Date	Deliverable	Deliverable Due Date
Monitoring Well Sampling[1]	Monitoring Well Sampling	U.S. EPA unless determined otherwise	TBD No sooner than 2 weeks after well development	2 weeks	TBD	Field Notes	Daily
	Laboratory Analysis	TBD	TBD	TBD	TBD	Laboratory reports and data packages	TBD
	Data Validation	U.S. EPA unless determined otherwise	TBD	TBD	TBD	Data validation summary reports	TBD
	Data Summarization	U.S. EPA unless determined otherwise	TBD	TBD	TBD	Data tables	TBD
	Data Usability Assessment	U.S. EPA unless determined otherwise	TBD	TBD	TBD	Data usability summary report	TBD
	Final Reporting	U.S. EPA unless determined otherwise	TBD	TBD	TBD	PDI Directive 1 Technical Memorandum Addendum	TBD

Notes:

(1) At this time, it is understood that U.S. EPA plans to collect groundwater samples from these newly installed monitoring wells and select existing monitoring wells (PDI Directive 1, Round 2).

TBD = To be determined at future project planning session(s).

QAPP WORKSHEET #15: PROJECT ACTION LIMITS AND LABORATORY — SPECIFIC DETECTION/QUANTITATION LIMITS

(UFP-QAPP Manual Section 2.6.2.3)

Detection Limits Compared and Action Levels — Water								
Method	**CAS No**	**Analyte**	**MDL (µg/L)**	**CRQL (µg/L)**	**WQS (µg/L)**	**MCL (µg/L)**	**Selected Criteria (µg/L)**	**MDL < Criteria?**
Volatile Organic Compounds								
Method 8260	75-71-8	Dichlorodifluoromethane	0.3712	1	5	NS	5	YES
Method 8260	74-87-3	Chloromethane	0.632	1	NS	NS	NS	YES
Method 8260	75-01-4	Vinyl chloride	0.4839	1	2	2	2	YES
Method 8260	74-83-9	Bromomethane	0.7356	1	5	NS	5	YES
Method 8260	75-00-3	Chloroethane	0.6414	1	5	NS	5	YES
Method 8260	75-69-4	Trichlorofluoromethane	0.2286	1	5	NS	5	YES
Method 8260	75-35-4	1,1-Dichloroethene	0.545	1	5	7	5	YES
Method 8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0.545	1	5	NS	5	YES
Method 8260	67-64-1	Acetone	1.879	1	NS	NS	NS	YES
Method 8260	75-15-0	Carbon disulfide	0.568	1	60	NS	60	YES
Method 8260	79-20-9	Methyl acetate	0.991	1	NS	NS	NS	YES
Method 8260	75-09-2	Methylene chloride	0.7665	1	5	5	5	YES
Method 8260	156-60-5	trans-1,2-Dichloroethene	0.558	1	5	100	5	YES
Method 8260	1634-04-4	Methyl tert-butyl ether	0.512	1	NS	NS	NS	YES
Method 8260	75-34-3	1,1-Dichloroethane	0.579	1	5	NS	5	YES
Method 8260	156-59-2	cis-1,2-Dichloroethene	0.499	1	5	70	5	YES
Method 8260	78-93-3	2-Butanone (MEK)	0.51	5	NS	NS	NS	YES
Method 8260	67-66-3	Chloroform	0.555	1	7	80	7	YES
Method 8260	71-55-6	1,1,1-Trichloroethane	0.317	1	5	200	5	YES
Method 8260	110-82-7	Cyclohexane	0.537	1	NS	NS	NS	YES
Method 8260	56-23-5	Carbon tetrachloride	0.326	1	5	5	5	YES
Method 8260	71-43-2	Benzene	0.585	1	1	5	1	YES
Method 8260	107-06-2	1,2-Dichloroethane	0.404	1	0.6	5	0.6	YES
Method 8260	79-01-6	Trichloroethene	0.473	1	5	5	5	YES
Method 8260	108-87-2	Methylcyclohexane	0.48	1	NS	NS	NS	YES
Method 8260	75-27-4	Bromodichloromethane	0.482	1	5	80	5	YES
Method 8260	78-87-5	1,2-Dichloropropane	0.454	1	1	5	1	YES
Method 8260	108-88-3	Toluene	0.571	1	5	1000	5	YES
Method 8260	10061-02-6	trans-1,3-Dichloropropene	0.505	1	0.4	NS	0.4	YES
Method 8260	10061-01-5	cis-1,3-Dichloropropene	0.464	1	NS	NS	NS	YES
Method 8260	108-10-1	4-Methyl-2-pentanone	0.356	1	NS	NS	NS	YES
Method 8260	79-00-5	1,1,2-Trichloroethane	0.488	1	1	5	1	YES
Method 8260	127-18-4	Tetrachloroethene	0.526	1	5	5	5	YES
Method 8260	591-78-6	2-Hexanone	0.745	1	NS	NS	NS	YES
Method 8260	124-48-1	Dibromochloromethane	0.505	1	NS	80	80	YES
Method 8260	106-93-4	1,2-Dibromoethane	0.404	1	NS	500	500	YES
Method 8260	108-90-7	Chlorobenzene	0.572	1	5	100	5	YES
Method 8260	100-41-4	Ethylbenzene	0.517	1	5	700	5	YES

Detection Limits Compared and Action Levels — Water								
Method	**CAS No**	**Analyte**	**MDL (µg/L)**	**CRQL (µg/L)**	**WQS (µg/L)**	**MCL (µg/L)**	**Selected Criteria (µg/L)**	**MDL < Criteria?**
Method 8260	1330-20-7	Xylenes (total)	0.466	3	5	NS	5	YES
Method 8260	100-42-5	Styrene	0.574	1	5	100	5	YES
Method 8260	75-25-2	Bromoform	0.611	1	NS	80	80	YES
Method 8260	98-82-8	Isopropylbenzene	0.396	1	5	NS	5	YES
Method 8260	79-34-5	1,1,2,2-Tetrachloroethane	0.388	1	5	NS	5	YES
Method 8260	541-73-1	1,3-Dichlorobenzene	0.464	1	5	NS	5	YES
Method 8260	106-46-7	1,4-Dichlorobenzene	0.476	1	5	75	5	YES
Method 8260	95-50-1	1,2-Dichlorobenzene	0.585	1	5	600	5	YES
Method 8260	96-12-8	1,2-Dibromo-3-chloropropane	0.661	1	0.04	20	0.04	NO
Method 8260	120-82-1	1,2,4-Trichlorobenzene	0.722	1	5	70	5	YES
1,4-Dioxane								
Method 522	123-91-1	1,4-Dioxane	0.55	1	NS	NS	NS	YES
Metals (Total and Dissolved)								
Method 6010	7429-90-5	Aluminum	31.48	200	NA	NA	NA	NA
Method 6010	7440-36-0	Antimony	20.82	60	NA	NA	NA	NA
Method 6010	7440-38-2	Arsenic	5.28	10	NA	NA	NA	NA
Method 6010	7440-39-3	Barium	13.73	200	NA	NA	NA	NA
Method 6010	7440-41-7	Beryllium	0.334	5	NA	NA	NA	NA
Method 6010	7440-42-8	Boron	0.6577	50	NA	NA	NA	NA
Method 6010	7440-43-9	Cadmium	0.3084	2.5	NA	NA	NA	NA
Method 6010	7440-70-2	Calcium	61.70	200	NA	NA	NA	NA
Method 6010	7440-47-3	Chromium	1.11	10	NA	NA	NA	NA
Method 6010	7440-48-4	Cobalt	3.98	50	NA	NA	NA	NA
Method 6010	7440-50-8	Copper	3.68	25	NA	NA	NA	NA
Method 6010	7439-89-6	Iron	19.91	20	NA	NA	NA	NA
Method 6010	7439-92-1	Lead	2.23	5	NA	NA	NA	NA
Method 6010	7439-95-4	Magnesium	16.16	200	NA	NA	NA	NA
Method 6010	7439-96-5	Manganese	2.93	10	NA	NA	NA	NA
Method 6010	7439-98-7	Molybdenum	5.35	20	NA	NA	NA	NA
Method 6010	7440-02-0	Nickel	4.41	40	NA	NA	NA	NA
Method 6010	7440-09-7	Potassium	1018	5000	NA	NA	NA	NA
Method 6010	7782-49-2	Selenium	7.05	10	NA	NA	NA	NA
Method 6010	7440-22-4	Silver	1.24	10	NA	NA	NA	NA
Method 6010	7440-23-5	Sodium	2340.6	5000	NA	NA	NA	NA
Method 6010	7440-24-6	Strontium	3.47	50	NA	NA	NA	NA
Method 6010	7440-28-0	Thallium	5.27	10	NA	NA	NA	NA
Method 6010	7440-31-5	Tin	5.41	50	NA	NA	NA	NA
Method 6010	7440-62-2	Vanadium	2.97	50	NA	NA	NA	NA
Method 6010	7440-66-6	Zinc	8.61	20	NA	NA	NA	NA
Other								
SM3500-Fe-W	15438-31-0	Ferrous Iron	77	100	NA	NA	NA	NA
SM2340B	—	Total Hardness (by calculation)	830	NA	NA	NA	NA	NA
SM2320B or Test Kit	—	Alkalinity	300	1000	NA	NA	NA	NA

Notes:

MDL	=	method detection limit
µg/L	=	micrograms per liter
CRQL	=	contract-required quantitation limit
WQS	=	New York State Department of Environmental Conservation Water Quality Standards
MCL	=	U.S. EPA Maximum Contaminant Level
TBD	=	To be determined
NS	=	no standard
NA	=	Not Applicable. Analyte is not a contaminant of concern and is being analyzed for the purpose of remedial design.

Laboratory-specific requirements will be incorporated into this table once the laboratory (Pace Analytical Services, LLC) is contracted. Method detection limits that do not meet applicable action levels are indicated as **NO** in the last column.
Method detection limits listed in this table are subject to change during the investigation.

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QAPP WORKSHEET #17: SAMPLING DESIGN AND RATIONALE

(UFP-QAPP Manual Section 3.1.1)

17.1 Vertical Profile Boring and Monitoring Well Installation

Groundwater samples will be collected from vertical profile soil borings with depth-discrete groundwater samples. Data obtained from these samples will be used to finalize monitoring well design, and estimate the horizontal and vertical extents and centerline positions of the Eastern Plume. Data will also be used to develop the Eastern Plume RD/RA. Locations of vertical profile borings and monitoring wells are shown on Figure 17-1.

For this project, vertical profile borings will be installed via Roto-Sonic technology and will include visual geologic logging of soils and analytical sampling of groundwater at the depths described in Table 17-1.

Table 17-1
Vertical Profile Borings

Profile Boring	Minimum Depth/ Maximum Depth[1] (feet bgs)	Target Sample Depth(s)[2] (feet bgs)	Target Frequency	Analysis	Notes
Transect T8					
PDI-40	450/520	40, 120 to 440/520	Every 20 feet	VOCs	Not required, pending PDI-41 results
PDI-41	450/520	40, 120 to 440/520	Every 20 feet	VOCs	
PDI-42	450/520	40, 120 to 440/520	Every 20 feet	VOCs	Not required, pending PDI-41 results
Transect T9					
PDI-43	450/520	40, 220 to 440/520	Every 20 feet	VOCs	May not be required, pending PDI-44 and PDI-45 results
PDI-44	450/520	40, 220 to 440/520	Every 20 feet	VOCs	
PDI-45	450/520	40, 220 to 440/520	Every 20 feet	VOCs	

Notes:

[1] With approval by U.S. EPA, the boring will be terminated at any depth below 450 feet bgs if two consecutive samples exhibit low VOC concentrations (less than 20 µg/L). A variance from the target depths may be requested based on the laboratory results. Deviations shall not be implemented until approved by U.S. EPA.

[2] Samples will be collected at the water table (expected at approximately 40 feet bgs) and then every 20 feet beginning at the identified depth.

bgs = below ground surface
VOC = volatile organic compound

The vertical profile borings will be completed as monitoring wells are installed, as described in Table 17-2.

Table 17-2
Monitoring Wells

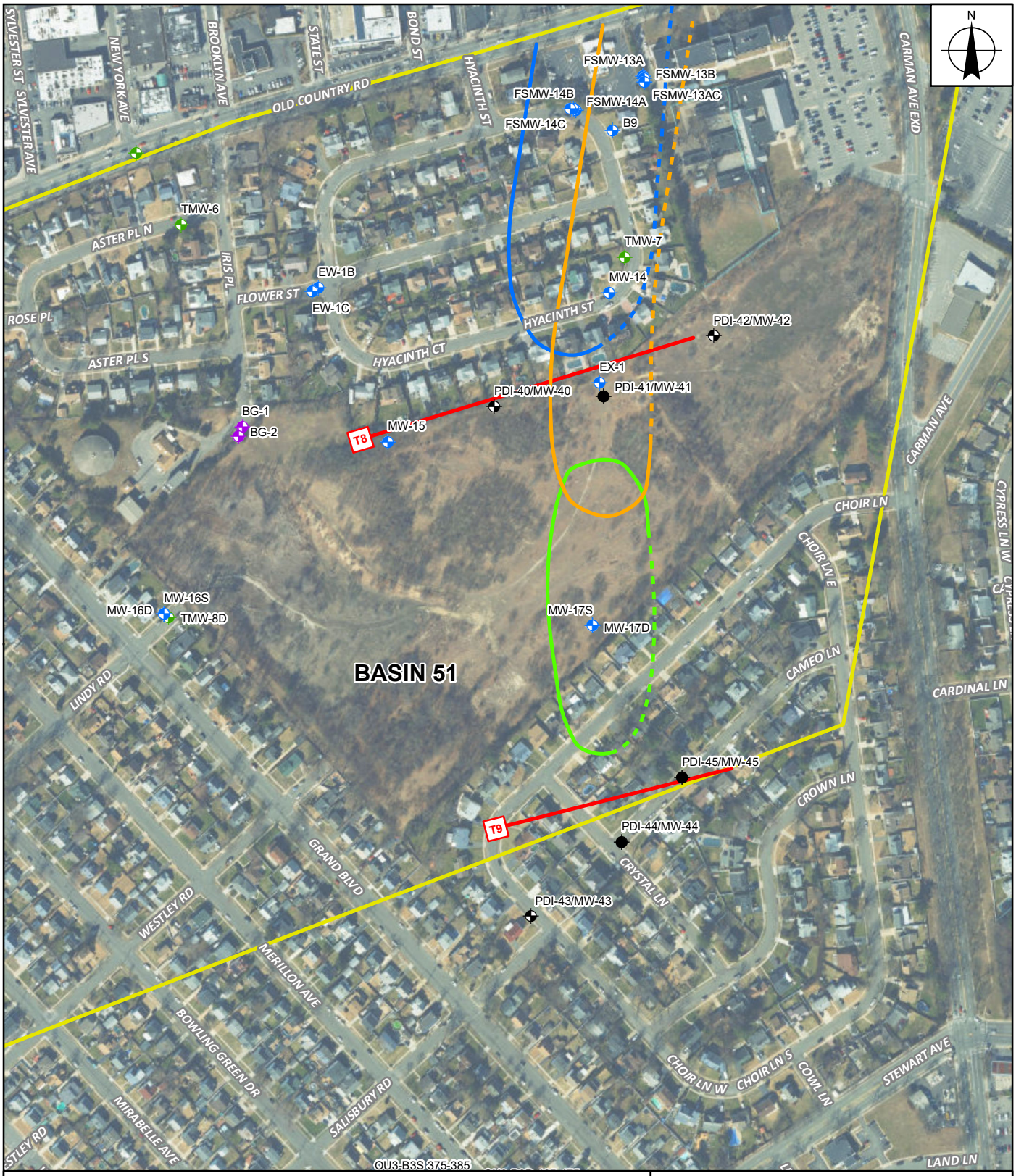
Monitoring Well[1]	Depth (feet bgs)	Screen Interval (feet bgs)	Notes[2]
Transect T8			
MW-40	-	-	Not required, pending PDI-41 results (If required: 1 well [shallow or intermediate, pending data])
MW-41	TBD	TBD	up to 2 wells (intermediate or deep, pending data)
MW-42	-	-	Not required, pending PDI-41 results (If required: 1 well [shallow or intermediate, pending data])
Transect T9			
MW-43	TBD	TBD	May not be required, pending PDI-44 and PDI-45 results (If required: 1 well [shallow or intermediate, pending data])
MW-44	TBD	TBD	up to 2 wells (intermediate or deep, pending data)
MW-45	TBD	TBD	1 well (shallow or intermediate, pending data)

Notes:
[1] Pending results of PDI-41, PDI-44, and PDI-45, some of these monitoring wells may not be required. This determination will be made by U.S. EPA.
[2] A shallow well depth means less than 275 feet bgs, an intermediate well depth means between 275 and 350 feet bgs, and a deep well depth shall mean greater than 350 feet bgs.
bgs = below ground surface
TBD = To be determined based on profile boring data, in consultation with and with approval by U.S. EPA.

17.2 Groundwater Sampling

At this time, it is understood that U.S. EPA plans to collect groundwater samples from these newly installed monitoring wells and select existing monitoring wells (PDI Directive 1, Round 2). Should U.S. EPA designate the Plume Group Respondents responsible for this sample collection, samples will be collected as described in this QAPP and Field Sampling Plan.

Prior to sampling, the depth to the static water level will be measured in all wells using an electronic water level meter in units of feet (to the nearest 0.01 foot) with respect to the top of the well casing to determine the depth-to-water below the ground surface. Water levels will be recorded on a water level measurement form. The water level meter will be decontaminated prior to use and between each monitoring well. The field QC samples required are specified in Worksheet #12. Detailed project tasks and schedule are summarized in Worksheets #14 and #16. The analytical program recommended for each proposed sample is presented in Worksheets #18, #19, #20, and #30. SOPs for field activities are summarized in Worksheet #21 and included as Appendix D.



LEGEND

- PROPOSED PROFILE BORING/ MONITORING WELL(S)
- PROPOSED PROFILE BORING/ MONITORING WELL(S) (PENDING DATA)
- EXISTING MONITORING WELL
- EXISTING TEMPORARY WELL
- EXISTING PUBLIC SUPPLY WELLS
- TRANSECTS
- EPA OU1 BOUNDARY
- 100 PPB (UG/L) CVOCS AT 150 FEET BGS (DASHED WHERE INFERRED)
- 100 PPB (UG/L) CVOCS AT 200 FEET BGS (DASHED WHERE INFERRED)
- 100 PPB (UG/L) CVOCS AT 285 FEET BGS (DASHED WHERE INFERRED)

NAD 1983 STATE PLANE NEW YORK ISLAND FEET

0 175 350

SCALE IN FEET

FIGURE 17-1
PDI SAMPLE LOCATIONS - EASTERN PLUME

REQUESTED BY:	AS
DRAWN BY:	MS
DATE:	4/11/2022
PROJECT:	0888820265

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X:\FrostStreet\PDISampleLocsV4.mxd

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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QAPP WORKSHEET #18: SAMPLING LOCATIONS AND METHODS

(UFP-QAPP Manual Section 3.1.1 and 3.1.2)

Sample Type	Sample ID[1]	Matrix	Sample Depth(s)[2] (feet below ground surface)	Type	Analyte/ Analytical Group[7]	Sampling SOP
Profile Boring	PDI-41-(sample depth)-MMDDYYYY	Groundwater	40; 120-440/520 (every 20 feet) (up to 22 samples)	Normal	VOCs	AD-02-01, FC-01-01, FD-01-01, FM-01-02, FQ-01-01, FS-03, and FT-02-01
	PDI-44-(sample depth)-MMDDYYYY		40; 220-440/520 (every 20 feet) (up to 17 samples)			
	PDI-45-(sample depth)-MMDDYYYY		40; 220-440/520 (every 20 feet) (up to 17 samples)			
Monitoring Well	Monitoring Well ID-MMDDYY	Groundwater	TBD	Normal	VOCs 1,4-dioxane Metals Other	AD-02-01, FC-01-01, FD-01-01, FM-01-02, FQ-01-01, FS-03, and FT-02-01
Trip Blank [3]	TB-MMDDYY	Aqueous (Lab-supplied)	NA	Quality Control	VOCs	AD-02-01, FC-01-01, FD-01-01, FM-01-02, FQ-01-01, FS-03, and FT-02-01
Field Duplicates [4]	FD-MMDDYY (location to be determined in the field)	Groundwater	TBD	Quality Control	VOCs 1,4-dioxane[8] Metals [8] Other[8]	AD-02-01, FC-01-01, FD-01-01, FM-01-02, FQ-01-01, FS-03, and FT-02-01
Matrix Spike/Matrix Spike Duplicate [5]	Location to be determined in the field	Groundwater	TBD	Quality Control	VOCs 1,4-dioxane[8] Metals[8] Other[8]	AD-02-01, FC-01-01, FD-01-01, FM-01-02, FQ-01-01, FS-03, and FT-02-01
Equipment Blanks [6]	EB-MMDDYY	Groundwater	NA	Quality Control	VOCs 1,4-dioxane[8] Metals[8] Other[8]	AD-02-01, FC-01-01, FD-01-01, FM-01-02, FQ-01-01, FS-03, and FT-02-01

Notes:

(1) If required, the naming convention for PDI-40, PDI-42, and PID-43 will follow that of PDI-41, PDI-44, and PDI-45.

(2) With approval by U.S. EPA, the boring will be terminated at any depth below 450 feet bgs if two consecutive samples exhibit low VOC concentrations (less than 20 µg/L). A variance from the target depths may be requested based on the laboratory results. Deviations shall not be implemented until approved by U.S. EPA.

(3) Trip blanks will be collected at a frequency of 1 per cooler containing VOC samples.

(4) Field duplicate will be collected at a frequency of 1 per 20 field samples, at least one collected per week.

(5) Matrix spike/matrix spike duplicate samples will be collected at a frequency of 1 per 20 field samples, at least one collected per week.

(6) Equipment blanks will be collected at a frequency of 1 per 20 field samples., per sampling equipment, at least one collected per week.

(7) See Worksheet #15 for full list of analytes.

(8) QA samples of samples collected from permanent monitoring wells will also include these analyses.

TBD = to be determined
SOP = standard operating procedure
MMDDYYYY = month (MM), day (DD), year (YYYY), (e.g., 10012020 for October 01, 2020)
NA = not applicable
VOCs = volatile organic compounds
TB-MMDDYYYY = trip blank month (MM), day (DD), year (YYYY), (e.g., 100120 for October 01, 2020)
FDMMDDYYYY = field duplicate month (MM), day (DD), year (YYYY), (e.g., 100120 for October 01, 2020)
EB-MMDDYYYY = equipment blank month (MM), day (DD), year (YYYY), (e.g., 100120 for October 01, 2020)

QAPP WORKSHEETS #19 and #30: SAMPLE CONTAINERS, PRESERVATION, AND HOLD TIMES

(UFP-QAPP Manual Section 3.1.2.2)

Laboratory Name: Pace Analytical Services LLC
Laboratory Address: 575 Broad Hollow Road, Melville, New York 11747
Laboratory Point of Contact: Lea Sherman, lea.sherman@pacelabs.com, 516-370-6000

Analytical Group	Matrix	Method	Accreditation Expiration Date	Containers (number, size, and type per sample)	Preservation Requirements (chemical, temperature, light-protected)	Maximum Holding Time (1) (preparation/ analysis)	Data Package Turnaround
Groundwater	VOCs	SW846 8260C	01 April 2022	3 — 40 mL glass vials	Hydrochloric acid to a pH less than 2; Cool to 0-6°C; no headspace	14 days to analysis	21 Days
Groundwater	1,4-Dioxane	Method 522	01 April 2022	1 — 1 L amber glass bottle	<10°C first 48 hours Sodium sulfite, sodium bisulfate	28 days to extraction	21 days
Groundwater	Metals (total)	SW846 6010C	01 April 2022	1 — 125 mL plastic bottle	Cooler to <6°C, Nitric acid to pH <2	180 days	21 Days
Groundwater	Metals (dissolved)(2)	SW846 6010C	01 April 2022	1 — 125 mL plastic bottle	Filter sample immediately with a 0.45-µm pore diameter filter Cooler to <6°C, Nitric acid to pH <2	180 days	21 Days
Groundwater	Ferrous iron	SM3500-Fe D	01 April 2022	1 — 100 mL amber glass bottle	Hydrochloric acid to a pH less than 2; Cool to <6°C	24 hours	21 Days
Groundwater	Total hardness	SM2340B	01 April 2022	1 — 250 mL plastic bottle	Cool to <6°C Nitric acid to pH <2	180 days	21 Days
Groundwater	Alkalinity	SM2320B	01 April 2022	1 — 100 mL plastic bottle	Cool to 0-6˚C	14 days	14 Days

Notes:

(1) Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/extracted.

(2) For samples requiring dissolved metal analyses, if field filtration of the sample was not performed at the time of collection, the unpreserved sample will be filtered by the laboratory upon receipt and recorded. The filtrates will be acid preserved (~5mL of 1+1 HNO3/liter) and verified to a pH of < 2. The samples are held for 24 hours prior to analysis.

VOCs = volatile organic compounds
mL = milliliters
µm = micrometer
L = liter
°C = degrees Celsius

QAPP WORKSHEET #20: FIELD QC SUMMARY

(UFP-QAPP Manual Section 3.1.1)

Matrix	Analyte/Analytical Group	# of Field Samples	Minimum # of Trip Blanks	Minimum # of Field Duplicates	Minimum # of Matrix Spikes	Minimum # of Matrix Spike Duplicates	Minimum # of Equipment Blanks	Minimum Total # Analyses (excluding trip blanks)
Groundwater (Profile Borings)	VOCs	56	One per cooler	3	3	3	3	68
Groundwater (Monitoring Wells)[2]	VOCs	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	1,4-Dioxane	TBD	0	TBD	TBD	TBD	TBD	TBD
	Metals (total and dissolved)	TBD	0	TBD	TBD	TBD	TBD	TBD
	Ferrous iron	TBD	0	0	0	0	0	TBD
	Total hardness	TBD	0	0	0	0	0	TBD
	Alkalinity	TBD	0	0	0	0	0	TBD

Notes:

(1) Trip blanks, field duplicates, matrix spikes, matrix spike duplicates, and equipment blanks will be collected based on the frequencies outlined in Worksheet #12. Quality control samples will be associated with samples in field records.

(2) At this time, it is understood that U.S. EPA plans to collect groundwater samples from these newly installed monitoring wells and select existing monitoring wells (PDI Directive 1, Round 2).

\# = number
VOCs = volatile organic compounds
TBD = to be determined

QAPP WORKSHEET #21: FIELD SOPs REFERENCE TABLE

SOP Reference Number	Title/Author	Revision Date or Version Number (1)	SOP Option or Equipment Type (if SOP provides different options)	Modified for Project?	Comments
AD-02-01	Sample Labeling and Chain-of-Custody/EnSafe	Revision 1; July 2019	—	No	—
FC-01-01	Decontamination of Field Equipment/EnSafe	Revision 1; September 2019	Applies to all equipment used for sampling	No	—
FD-01-01	Field Documentation/EnSafe	Revision 1; September 2019	—	No	—
FM-01-02	Packing and Shipping of Non-hazardous Environmental Samples/EnSafe	Revision 2; July 2019	—	No	Blue ice will not be used.
FQ-01-01	Quality Assurance/Quality Control Sampling/EnSafe	Revision 1; September 2019	—	No	—
FS-03	Groundwater Sampling/EnSafe	Revision 1; May 2020	Applies to all equipment used for sampling	No	—
FT-02-01	Water Quality Parameter Testing/EnSafe	Revision 1; July 2019	—	No	—

Notes:
(1) The most recent version of the procedure at the time of sampling will be used.
SOP = standard operating procedure

QAPP WORKSHEET #22: FIELD EQUIPMENT CALIBRATION, MAINTENANCE, TESTING, AND INSPECTION

(UFP-QAPP Manual Section 3.1.2.4)

Field Equipment	Activity[1]	SOP Reference	Title or Position of Responsible Person	Frequency	Acceptance Criteria	Corrective Action
Water Quality Meter YSI 556 (or equivalent)	Visual Inspection Calibration/ Verification	FT-02-01 Manufacturer's Guidance Manual	Field Team Leader or designee	Daily, beginning of each day, and as required by the specific instrument and SOP	pH ± 0.2 standard units Specific conductance ± 5% Dissolved oxygen ± 0.03 milligrams per liter Temperature ±0.2 degrees Celsius Oxygen reduction potential ± 10 millivolts	Operator correction or replacement
Turbidity Meter Hach 2100Q (or equivalent)	Visual Inspection Calibration/ Verification	FT-02-01 Manufacturer's Guidance Manual	Field Team Leader or designee	Daily, beginning of each day, and as required by the specific instrument and SOP	The acceptance criterion for the initial calibration verification depends on the range of turbidity of the standard value: 0.1-10 NTU: within 10% of the standard 11-40 NTU: within 8% of the standard 41-100 NTU: within 6.5% of the standard	Operator correction or replacement
Water Level Indicator	Visual Inspection Field checks as per manufacturer	Manufacturer's Guidance Manual	Field Team Leader or designee	Daily, beginning of each day, and as required by the specific instrument and SOP	0.01-foot accuracy	Operator correction or replacement
QED MP50 Bladder Pump (or similar)	Visual Inspection Field checks as per manufacturer	Manufacturer's Guidance Manual	Field Team Leader or designee	Daily, beginning of each day, and as required by the specific instrument and SOP	Pump is variable speed and therefore, acceptance is based on pump's ability to pump at rate necessary to achieve stable flow from various wells.	Operator correction or replacement

Notes:

(1) Activities may include: calibration, verification, testing, maintenance, and /or inspection.

SOP = standard operating procedure

% = percent

NTU = nephelometric turbidity units

Field measurement equipment will be checked for operation in accordance with the manufacturer's specifications. This includes battery checks, routine replacement of membranes, and cleaning of conductivity electrodes. All equipment will be inspected for damage when first handed out and when returned from use. Equipment used to gather, generate, or measure environmental data will be calibrated within the frequency stipulated by the SOP and manufacturer's instructions in such a manner that accuracy and reproducibility of results are consistent.

Prior to use, field measuring equipment will be examined to verify that it is in operating condition and field personnel will follow the manufacturer's instructions for assembly, operation, and maintenance of field instruments and equipment. Inspections of instruments prior to their use shall consist of a general examination of the probes, wires, and electrical systems (battery check) and calibration check. If a field instrument proves faulty, the equipment will be taken out-of-service until corrective action can be performed to return the unit to working order. If appropriate, a substitute unit will be delivered to the Site to ensure that the integrity of the work is not compromised.

Field personnel will verify that the SOP calibration requirements have been met for instruments used and that all equipment is in proper working condition prior to use. They will document acceptable calibration and calibration verification for each instrument unit and field test or analysis, linking this record with affected sample measurements. The preventive maintenance of field equipment is described in detail in the associated manufacturers' equipment manuals. Records of equipment maintenance will be maintained in the field logbook.

Instruments may also be re-calibrated during the day if field personnel consider it necessary. Instrument calibration will be recorded in the field logbook or on project-specific calibration forms. Field instruments will be calibrated according to SOPs in Appendix D.

Whenever field measurements do not fall within acceptance limits, corrective action should be taken to bring the analysis back into control. The corrective action should include: (1) finding the cause of the problem, (2) correcting the problem, including replacing equipment, (3) demonstrating the problem has been corrected by reanalyzing appropriate laboratory reference samples, if necessary, and (4) repeating the analyses of any investigative samples that may have been affected by the control problem, if necessary. Any preventative or corrective maintenance completed will be documented in the field notes.

QAPP WORKSHEET #23: ANALYTICAL SOP REFERENCES TABLE

(UFP-QAPP Manual Section 3.2.1)

Laboratory Name: Pace Analytical Services LLC
Laboratory Address: 575 Broad Hollow Road, Melville, New York 11747
Laboratory Point of Contact: Lea Sherman, lea.sherman@pacelabs.com,

Lab SOP Number	Title and Revision Number	Definitive or Screening Data	Matrix /Analytical Group	Instrument	Modified for Project Work? (Y/N)
ENV-SOP-MELV-0101	Analysis of Volatile Organics by GC/MS — Method 8260C; Revision 02	Definitive	Groundwater — VOCs	GC/MS	No
ENV-SOP-MELV-0062	Sample Preparation and Analysis of the Determination of Trace Metals by Inductively-coupled Plasma Atomic Emission Spectroscopy — Method 6010C and Prep. Methods 3005A and 3050B; Revision 03	Definitive	Groundwater — Metals (total and dissolved)	ICP-AES	No
ENV-SOP-GBUR-0142	Ferrous Iron – SmartChem; Revision 01	Screening	Groundwater — Ferrous iron	Colorimetric	—
ENV-SOP-MELV-0127	Hardness by Calculation by SM 2340B; Revision 01	Screening	Groundwater — Hardness	NA	No
ENV-SOP-MELV-0027	Total Alkalinity Analysis in Water by Titrimetric technique (pH 4.5) — Method 2320B; Revision 01	Screening	Groundwater — Alkalinity	Titration — automatic	No

Notes:

SOP = standard operating procedure
Y/N = yes or no
VOCs = volatile organic compounds
GC/MS = gas chromatography/mass spectroscopy
ICP-AES = inductively-coupled plasma/atomic emission spectroscopy
SM = Standard Method
NA = not applicable

QAPP WORKSHEET #24: ANALYTICAL INSTRUMENT CALIBRATION

(UFP-QAPP Manual Section 3.2.2)

Instrument	Calibration Procedure	Frequency	Acceptance Criteria	Corrective Action (CA)	Title/Position of Person Responsible for Corrective Action	SOP Reference
GC/MS VOCs	Tuning	Prior to ICAL and at the beginning of each 12-hour period.	Refer to method for specific ion criteria.	Retune instrument and verify	Analyst, Supervisor, Department Manager	ENV-SOP-MELV-0101
GC/MS VOCs	ICAL All analytes including surrogates	At instrument set-up and after ICV or CCV failure, prior to sample analysis	Each analyte must meet one of the following: Option 1: %RSD for each analyte ≤15%; Option 2: linear least squares regression for each analyte: r^2 ≥0.99; Option 3: non-linear least squares regression (quadratic) for each analyte: r^2≥0.99.	Correct problem then repeat ICAL	Analyst, Supervisor, Department Manager	ENV-SOP-MELV-0101
GC/MS VOCs	RRT Evaluation	Prior to sample analysis	RRT of each target analyte within ±0.06 RRT units of the RRT standard; RRTs may be updated based on the daily CCV	Correct problem, then rerun ICAL	Analyst, Supervisor, Department Manager	ENV-SOP-MELV-0101
GC/MS VOCs	ICV	Once after each ICAL, analysis of a second source standard prior to sample analysis	All reported analytes within ± 20% of true value	Correct problem, rerun ICV, if that fails, repeat ICAL	Analyst, Supervisor, Department Manager	ENV-SOP-MELV-0101
GC/MS VOCs	CCV	Daily before sample analysis; after every 12 hours of analysis time; and at the end of the analytical batch run	All reported analytes and surrogates within ±20% of true value All reported analytes and surrogates within ±50% for end of analytical batch CCV	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails or if two consecutive CCVs cannot be run, perform corrective action(s) and repeat CCV and all associated samples since last successful CCV. Alternately, recalibrate if necessary; then reanalyze all associated samples since the last acceptable CCV.	Analyst, Supervisor, Department Manager	ENV-SOP-MELV-0101
ICP-AES Metals	Initial demonstration of capability	Initially during the method development, and any time thereafter, if there is significant change in instrument type, personnel, methodology, or matrix or a period greater than 1 year has lapsed since last performance of analysis	See SOP for acceptance criteria	Recalculate results; locate and fix problem, then rerun demonstration for those analytes that did not meet criteria	Analyst, Supervisor, Department Manager	ENV-SOP-MELV-0062
ICP-AES Metals	Instrument detection limit	At initial set-up and after significant change in instrument type, personnel, test method, or sample matrix	Instrument detection limit ≤ reporting limit	Redo — samples cannot be analyzed without a valid instrument detection limit.	Analyst, Supervisor, Department Manager	ENV-SOP-MELV-0062
ICP-AES Metals	Linear dynamic range or high-level check standard (ICP only)	Every 6 months	Within ± 10% of true value	Correct problem	Analyst, Supervisor, Department Manager	ENV-SOP-MELV-0062
ICP-AES Metals	ICAL ICP: minimum one high standard and a calibration blank	ICAL prior to sample analysis	If more than one calibration standard is used, r ≥ 0.995	Correct problem, then repeat ICAL	Analyst, Supervisor, Department Manager	ENV-SOP-MELV-0062
ICP-AES Metals	Second source calibration verification (ICV)	Once after each ICAL, prior to beginning a sample run	Value of second source for all analyte(s) within ± 10% of true value	Correct problem and verify second source standard, rerun ICV, if that fails, correct problem and repeat ICAL	Analyst, Supervisor, Department Manager	ENV-SOP-MELV-0062
ICP-AES Metals	Continuing calibration verification (CCV)	After every 10 field samples and at the end of the analysis sequence	ICP: within ± 10% of true value	Correct problem, rerun calibration verification, if that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification	Analyst, Supervisor, Department Manager	ENV-SOP-MELV-0062
ICP-AES Metals	Low-level calibration check standard (ICP only)	Daily, after one-point ICAL	Within ± 20% of true value	Correct problem, then reanalyze	Analyst, Supervisor, Department Manager	ENV-SOP-MELV-0062
ICP-AES Metals	Interference check solutions (ICS) (ICP only)	At the beginning of an analytical run.	ICS-A: Absolute value of concentration for all non-spiked analytes < detection limit (unless they are a verified trace impurity from one of the spiked analytes); ICS-AB: Within ± 20% of true value	Terminate analysis; locate and correct problem; reanalyze ICS, reanalyze all samples	Analyst, Supervisor, Department Manager	ENV-SOP-MELV-0062
Colorimetric	ICAL — for all analytes: A series of five standards in order of decreasing concentration and a calibration blank	Daily initial calibration prior to sample analysis	r^2 ≥ 0.995	Correct problem, then repeat ICAL	Analyst, Supervisor, Department Manager	ENV-SOP-GBUR-0142
Colorimetric	CCV	At the beginning of analysis; after every 10 field samples, and at the end of the analysis sequence	Recoveries should fall within 90% - 110%	Correct problem, then rerun calibration verification, if that fails, then repeat ICAL Reanalyze all samples since the last successful calibration verification	Analyst, Supervisor, Department Manager	ENV-SOP-GBUR-0142

Instrument	Calibration Procedure	Frequency	Acceptance Criteria	Corrective Action (CA)	Title/Position of Person Responsible for Corrective Action	SOP Reference
Colorimetric	Linear Calibration Range	Upon method/instrument setup, per analyte/method/matrix combination, and every 6 months thereafter or whenever a significant change in instrument response is observed or expected	All analytes within ±10% of initial value	Re-establish linearity. Sufficient standards must be used to clearly define the non-linear portion of the calibration curve.	Analyst, Supervisor, Department Manager	ENV-SOP-GBUR-0142

Notes:
SOP = standard operating procedure
GC/MS = gas chromatograph/mass spectrometer
VOCs = volatile organic compounds
ICP-AES = inductively-coupled plasma-atomic emission spectrometry
ICAL = initial calibration
ICV = initial calibration verification
CCV = continuing calibration verification
%RSD = relative standard deviation
≤ = less than or equal to
r^2 = least squares regression coefficient/coefficient of determination
% = percentage
≥ = greater than or equal to
RRT = relative retention time
RT = retention time

QAPP WORKSHEET #25: ANALYTICAL INSTRUMENT AND EQUIPMENT MAINTENANCE, TESTING, AND INSPECTION

(UFP-QAPP Manual Section 3.2.3)

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Title/Position Responsible for Corrective Action	SOP Reference
GC/MS	Check pressure and gas supply daily Bake trap/column, manual tune if criteria is not met Perform the following as needed: change septa, cut/replace column, change trap, clean source, clean injection port/liner	VOCs	Ion source, injector liner, column flow Monitor instrument performance via calibrations and blanks	Prior to ICAL and/or as necessary	Calibration and QC criteria met	Repeat maintenance activity, correct problem, or remove from service	Analyst, Supervisor, Department Manager	ENV-SOP-MELV-0101
ICP-AES	Check pressure and gas supply daily Replace pump tubing as needed Clean nebulizer, spray chamber and torch as needed Replace or clean sample and skimmer cone	Metals (total and dissolved)	Torch, nebulizer, spray chamber, pump tubing Monitor instrument performance via calibrations and blanks	Prior to initial calibration and/or as necessary	Calibration and QC criteria met	Repeat maintenance activity, correct problem, or remove from service	Analyst, Supervisor, Department Manager	ENV-SOP-MELV-0062
Colorimeter	Change tubing and lamp as needed	Ferrous iron	Clean and check injection syringe and mixer alignment daily Monitor instrument performance via calibrations and blanks	Prior to initial calibration and/or as necessary	Calibration and QC criteria met	Repeat maintenance activity, correct problem, or remove from service	Analyst, Supervisor, Department Manager	ENV-SOP-GBUR-0142

Notes:
SOP = standard operating procedure
GC/MS = gas chromatograph/mass spectrometer
VOCs = volatile organic compounds
ICP = inductively-coupled plasma
AES = atomic emission spectrometry
ICAL = initial calibration
QC = quality control

QAPP WORKSHEETS #26 and #27: SAMPLE HANDLING, CUSTODY, AND DISPOSAL

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT	
Sample Collection (Personnel/Organization):	EnSafe Field Team Leader
Sample Packaging (Personnel/Organization):	EnSafe Field Team Leader
Coordination of Shipment (Personnel/Organization):	EnSafe Field Team Leader
Type of Shipment/Carrier:	Federal Express
SAMPLE RECEIPT AND ANALYSIS	
Sample Receipt (Personnel/Organization):	Sample Receiving Group: Pace Analytical Services, LLC
Sample Custody and Storage (Personnel/Organization):	Sample Receiving Group: Pace Analytical Services, LLC
Sample Extraction (Personnel/Organization):	Sample Extraction Personnel: Pace Analytical Services, LLC
Sample Determinative Analysis (Personnel/Organization):	Sample Analysis Personnel: Pace Analytical Services, LLC
SAMPLE ARCHIVING	
Field Sample Storage (Number of days from sample collection):	45 Days from Receipt of Samples
Sample Extract/Digestate Storage (Number of days from extraction/digestion):	45 Days from Receipt of Samples
SAMPLE DISPOSAL	
Personnel/Organization:	Waste Compliance Manager: Pace Analytical Services, LLC
Number of Days from Analysis:	45 Days from Receipt of Samples

Sample Collection Documentation

Documentation of field observations will be recorded in a field logbook and/or field log sheets including daily field forms, sample collection logs, boring logs, and monitoring well construction logs. These documents will be used to record information about each sample including the sample identification number, sample time and date, location, sample matrix, and analytical matrix. Field sample log sheets will be used to document sample collection details and other observations and activities will be recorded in the field logbook. Instrument calibration logs will be used to record the daily instrument calibration.

For sampling and field activities, the following types of information will be recorded in the field logbook/field forms as appropriate:

- Site name and location
- Date and time of logbook entries
- Personnel and their affiliations
- Weather conditions
- Activities involved with the sampling
- Subcontractor activity summary
- Site observations including Site entry and exit times
- Site sketches made onsite
- Visitor names, affiliations, arrival, and departure times
- Health and safety issues, including personal protective equipment

Sample Handling and Tracking System

The laboratories will provide clean sample containers for sample collection. Samples will be preserved, as indicated on Worksheets #19 and #30, based on the analytical method. Proper custody procedures will be followed throughout all phases of sample collection and handling.

Following collection, all samples will be immediately placed on ice in a cooler. The glass sample containers will be enclosed in bubble-wrap to protect the bottle ware during shipment. Samples will be packed with wet ice as required, in each cooler. A temperature blank (a small polypropylene bottle or 40-millileter [mL] vial filled with de-ionized water) will be placed in each cooler and will be used to determine the core temperature of the received samples by the laboratory technician. The cooler will be secured using strapping tape along with signed custody seals. One copy of the chain-of-custody will be placed in each cooler.

After collection, each sample will be maintained in the sampler's custody until formally transferred to another party (e.g., commercial courier). For all samples collected, chain-of-custody forms will document the date and time of sample collection, the sampler's name, and the names of all others who subsequently held custody of the sample. Specifications for chemical analyses will also be documented on the chain-of-custody form. SOP AD-02-01 (Appendix D) provides further details on the chain-of-custody procedure.

EnSafe personnel will collect the samples. The samplers will take care not to contaminate samples through improper handling. Samples will be sealed in appropriate containers, packaged by personnel, and placed into sealed coolers under chain-of-custody in accordance with the applicable SOP. All coolers will contain a temperature blank. Samples will be transferred under chain-of-custody to a courier as described below. Once received by the laboratory(s), receipt will be documented on the chain-of-custody form and the samples will be checked in. The samples will remain under chain-of-custody throughout the analysis period to ensure their integrity is preserved. Details are provided below.

The following subsections outline the procedures that will be used by field and laboratory personnel to document project activities and sample collection procedures. All forms must be filled in as completely as possible.

Field Sample Custody Procedures

Chain-of-custody protocols will be used throughout sample handling to establish the evidentiary integrity of sample containers. These protocols will be used to demonstrate that the samples were handled and transferred in a manner that would eliminate possible tampering. Samples for the laboratory will be packaged and shipped in accordance with SOP FM-01-02 (Appendix D).

A sample is under custody if:

- The sample is in the physical possession of an authorized person.
- The sample is in view of an authorized person after being in his/her possession.
- The sample is placed in a secure area by an authorized person after being in his/her possession.
- The sample is in a secure area, restricted to authorized personnel only.

Custody documentation is designed to provide documentation of preparation, handling, storage, and shipping of all samples collected. Each chain-of-custody is signed and dated by the recipient of a sample or portion of sample. The person releasing the sample and the person receiving the sample each will retain a copy of the form each time a sample transfer occurs. Chain-of-custody forms will be completed daily to manage samples and to track samples for shipment.

Chain-of-custody forms include the following information:

- Sample identification number
- Sample matrix
- Sample time
- Sample date
- Analytical methods
- Project number
- Site name
- Types of sample preservative
- Custody signatures and the date and time of receipt/relinquishment

Integrity of the samples collected will be the responsibility of identified persons from the time the samples are collected until the samples, or their derived data, are incorporated into the final report.

The Field Team Leader (FTL) is responsible for the care and custody of the samples collected until they are delivered to the laboratory or are entrusted to a carrier. When transferring samples, the individuals relinquishing and receiving them will sign, date, and note the time on the chain-of-custody form. This record documents the sample custody transfer from the sampler to the laboratory, often through another person or agency (commercial courier). Upon arrival at the laboratory, internal sample custody procedures will be followed as defined in the laboratory SOPs (Appendix D).

Laboratory Chain-of-Custody

Laboratory sample custody procedures (receipt of samples, archiving, and disposal) will be used in accordance with the laboratory's SOPs. Coolers are received and checked for proper temperature. A sample cooler receipt form will be filled out to note conditions and any discrepancies. The chain-of-custody form will be checked against the sample containers for accuracy. Samples will be logged into the laboratory information management system and given a unique log number, which can be tracked through processing. The laboratory project manager will notify the FTL or chemist verbally or via email immediately of any problems on the same day that an issue is identified. Discrepancies and resolutions will be documented on the sample receiving checklist.

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION

(UFP-QAPP Manual Section 3.4)

Matrix	**Groundwater**					
Analytical Group	**VOCs**					
Analytical Method/SOP	**Gas Chromatographic Analysis** **SW-846: 8260C / ENV-SOP-MELV-0101**					
QC Check	**Minimum Frequency**	**Acceptance Criteria**	**Corrective Action**	**Flagging Criteria**	**Person Responsible for Corrective Action**	**Comments**
Internal Standards	All field and QC samples	Peak areas within -50% to +100% of the area in the associated reference standard. Retention time within 30 seconds of RT for associated reference standard	Inspect instrument for malfunctions and correct problem Reanalyze all samples with internal standard failures if corrective action fails, data must be qualified and explained in the case narrative	If reanalysis cannot be performed, data must be qualified and explained in the case narrative	Analyst, Supervisor, Department Manager	Flagging is only appropriate in cases where the samples cannot be reanalyzed
Method Blank (MB)	Performed during each tune period after the ICAL or CCV (minimum of 1 MB per 20 samples)	Must meet internal standard criteria Must meet surrogate criteria Quantitative results for all target compounds must be less than the reporting limit for the associated samples	Inspect instrument for malfunctions and correct problem If the MB contains target analytes and the associated samples do not, then no corrective action is required If the target compounds in the MB are also in the associated samples, then they must be reanalyzed after a clean MB is obtained (certain projects may allow some exceptions for common laboratory contaminants like methylene chloride and acetone up to five times the LOQ).	If reanalysis cannot be performed, data must be qualified and explained in the case narrative Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch	Analyst, Supervisor, Department Manager	Results may not be reported without a valid method blank Flagging is only appropriate in cases where the samples cannot be reanalyzed
Laboratory Control Sample **Laboratory Control Sample Duplicate**	LCS analyzed with each batch of ≤ 20 samples LCSD analyzed if MS/MSD unavailable	Must meet internal standard criteria Must meet surrogate criteria All % recoveries must fall within statistically-derived QC limits, which are evaluated on a semi-annual basis	If non-compliant, check for calculation or preparation errors, if no errors found, check system for problems and reanalyze If LCS/LCSD re-analysis still fails, perform appropriate system maintenance, and restart the tune period Only with an LCS % recovery failing high (for the requested target compounds) with targets non-detected in the sample, can the results be reported, otherwise, the sample must be analyzed with a compliant LCS	If reanalysis cannot be performed, data must be qualified and explained in the case narrative Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch	Analyst, Supervisor, Department Manager	Results may not be reported without a valid LCS Flagging is only appropriate in cases where the samples cannot be reanalyzed
Matrix Spike **Matrix Spike Duplicate**	MS/MSD analyzed with each batch of ≤ 20 samples (if sufficient sample volume available)	% Recoveries must fall within statistically-derived QC limits, which are evaluated on a semi-annual basis RPDs within QC limits	If LCS within QC limits, proceed with sample analysis If most recoveries and/or RPDs are outside of QC limits, consult the supervisor	For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the case narrative	Analyst, Supervisor, Department Manager	If MS results are outside the limits, the data shall be evaluated to determine the source(s) of difference, i.e., matrix effect or analytical error
Surrogate Spike	All field and QC samples	All % recoveries must fall within statistically-derived QC limits, which are evaluated on a semi-annual basis	Correct problem, then re-prep and reanalyze all failed samples for all surrogates in the associated preparatory batch, if sufficient sample material is available If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary	Apply Q-flag to all associated analytes if acceptance criteria are not met and explain in the case narrative	Analyst, Supervisor, Department Manager	Alternative surrogates are recommended when there is obvious chromatographic interference

Notes:

VOCs = volatile organic compounds
SOP = standard operating procedure
QC = quality control
ICAL = initial calibration
CCV = continuing calibration verification
≤ = less than or equal to
LOQ = limit of quantitation
LCS = laboratory control sample
LCSD = laboratory control sample duplicate
MB = method blank
MS/MSD = matrix spike/matrix spike duplicate
RPD = relative percent difference
RT = retention time
% = percentage

Matrix	**Groundwater**					
Analytical Group	**Metals (total and dissolved)**					
Analytical Method/SOP	**Inductively-coupled plasma-atomic emission spectrometry/ENV-SOP-MELV-0062**					
QC Check	**Minimum Frequency**	**Acceptance Criteria**	**Corrective Action**	**Flagging Criteria**	**Person Responsible for Corrective Action**	**Comments**
Method Blank	One per batch or one per 20 samples or 8-hour window (whichever is most frequent) Processed with, and under the same conditions as, samples and goes through all the steps of the analytical procedure	Target analytes should be less than 10% of the lower limit of CRDL, less than 10% of the RL, or less than 10% of the lowest sample concentration for each analyte in a given preparation batch, whichever is greater If blank is >CRDL, associated samples must be <10X the prep blank results	If the method blank cannot be considered acceptable, the method blank should be re-run once, and if still unacceptable, then all samples after the last acceptable method blank should be re-prepared and reanalyzed along with the other appropriate batch QC samples	None Do notproceed with analysis	Analyst, Supervisor, Department Manager	Flagging is only appropriate in cases where the samples cannot be reanalyzed
Laboratory Control Sample	Performed during each tune period after the ICAL or CCV (minimum of 1 MB per 20 samples)	When evaluated as an ICV, the criteria of90-110% recoverymust be met. When evaluated as an LCS, the methodrequirement of 80-120% recovery must be met unless the LCS is a solid CRM, and then the manufacturer's acceptance limits can be used	Redigest and reanalyze all samples associated with theLCS Reanalyze all samples associated with the ICV; if reanalysis of samples is not possible, report data flagged toindicate LCS failed recovery	None Do notproceed with analysis	Analyst, Supervisor, Department Manager	Flagging is only appropriate in cases where the samples cannot be reanalyzed
Matrix Spike/Matrix Spike Duplicate	Must run after the CCV if not clean MB is analyzed at the beginning of a 12-hour analytical period	One per batch or one per 20 samples,whichever is more frequent	Recovery: 75-125%, unless analyte concentration is >4x the spike level ≤20% RPD for MSD	If the recovery is outside thelimits, repeat the sample, duplicate, and matrix spike analysis once; If it passes, then report samples Check for errors in calculationand spike preparation If the matrix spike still exceedsthe limits, but the LCS/ICV has acceptable recovery, then the method is in control and sample matrix effects are likelythe cause. The data should bequalified in the case narrative or using QC notes in the LIMS for non-package work	Analyst, Supervisor, Department Manager	Flagging is only appropriate in cases where the samples cannot be reanalyzed
Post Digestion Spike addition	If MS is outside of limits orif matrix interference is suspected Same frequency andsample as MS	Recovery: 80-120%	If the recovery of the analyte(s)is not within the specified limits, a matrix effect should be suspected, and the associateddata flagged accordingly	If reanalysis cannot be performed, data must be qualified and explained in the case narrative	Analyst, Supervisor, Department Manager	Flagging is only appropriate in cases where the samples cannot be reanalyzed
Serial Dilution	At least one ICP serial dilution sample analysis is performed on each group of samples of a similar matrix type (e.g., water, soil) and concentration level (i.e., low, medium) or for each SDG, whichever is more frequent	If the element concentrations exceed the instrumental detection limit (IDL) by a factor of 50 or greater, a 5X dilutionof the original sample must be within 10%	Evaluate dilution preparation; ifthe recovery of the analyte(s) is not within the specified limits,the associated data should be flagged accordingly	Qualify outages andexplain in case narrative	Analyst, Supervisor, Department Manager	Flagging is only appropriate in cases where the samples cannot be reanalyzed
Duplicate	One per batch or one per 20 samples, whichever is more frequent.	≤20% RPD For result values lessthan five times the PQL, a control limit of ± the PQL will be used	Check sample label, calculation, dilution factors. If results are grossly different (i.e., very high result and non-detect) re-analyze to confirm	Qualify outages andexplain in case narrative	Analyst, Supervisor, Department Manager	Flagging is only appropriate in cases where the samples cannot be reanalyzed
Internal Standards	With each batch	Should not deviate more than 60-125%of the original response in the calibration blank	Check operating conditions and sample introduction	None Do notproceed with analysis	Analyst, Supervisor, Department Manager	Results may not be reported without a valid internal standard

Notes:

SOP	=	standard operating procedure
QC	=	quality control
ICAL	=	initial calibration
CCV	=	continuing calibration verification
ICP	=	inductively-coupled plasma
≥	=	greater than or equal to
>	=	less than
<	=	greater than
%	=	percentage
MS/MSD	=	matrix spike/matrix spike duplicate
LCS	=	laboratory control sample
LOQ	=	limit of quantitation
RPD	=	relative percent difference
SDG	=	sample delivery group
RL	=	report limit
ICV	=	initial calibration verification

Matrix	Groundwater					
Analytical Group	Ferrous Iron					
Analytical Method/SOP	Automated Colorimetric / ENV-SOP-GBUR-0142					
QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Person Responsible for Corrective Action	Comments
Method Blank	Analyze one per batch of up to 20 samples	No analytes detected greater than the reporting limit	Correct problem, then re-analyze method blank and all samples processed with contaminated blank	If reanalysis cannot be performed, data must be qualified and explained in the case narrative Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch	Analyst, Supervisor, Department Manager	Results may not be reported without a valid method blank Flagging is only appropriate in cases where the samples cannot be reanalyzed
Laboratory Control Sample **Laboratory Control Sample Duplicate**	Analyze one per batch of up to 20 samples	See lab SOP for QC acceptance criteria	Correct problems, then re-analyze the LCS and all samples in the affected batch	If reanalysis cannot be performed, data must be qualified and explained in the case narrative Apply flag to specific analyte(s) in all samples in the associated preparatory batch	Analyst, Supervisor, Department Manager	Results may not be reported without a valid laboratory control sample Flagging is only appropriate in cases where the samples cannot be reanalyzed
Matrix Spike **Matrix Spike Duplicate**	One MS/MSD per every 20 project samples per matrix	See lab SOP for QC acceptance criteria	If LCS within QC limits, proceed with sample analysis If most recoveries and/or RPDs outside of QC limits, consult the supervisor	For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the case narrative	Analyst, Supervisor, Department Manager	If MS results are outside the limits, the data shall be evaluated to determine the source(s) of difference, e.g., matrix effect or analytical error.

Notes:

SOP = standard operating procedure
QC = quality control
% = percentage
LCS = laboratory control sample
MS/MSD = matrix spike / matrix spike duplicate
≤ = less than or equal to
RPD = relative percent difference
> = greater than

QAPP WORKSHEET #29: PROJECT DOCUMENTS AND RECORDS

(UFP-QAPP Manual Section 3.5.1)

Sample Collection and Field Records			
Record	**Generation**	**Verification**	**Data Assessment Documents and Records**
Project personnel sign-off record	PM — Alexandra Stark	PM — Alexandra Stark	Project File
Field logbook/Field sampling data sheets	FTL — TBD	PM — Alexandra Stark	Project File
Sample documentation forms	FTL — TBD	PM — Alexandra Stark	Project File
Tailgate safety meeting forms	FTL — TBD	PM — Alexandra Stark	Project File
Chain-of-custody (COC) forms	FTL — TBD	QAO — Tina Clemmey	Project File
Sample shipment air bills	FTL — TBD	PM — Alexandra Stark	Project File
Custody seals	FTL — TBD	QAO — Tina Clemmey	Project File
Deviations	FTL — TBD	PM — Alexandra Stark and QAO — Tina Clemmey	Project File
Corrective action reports	FTL — TBD	PM — Alexandra Stark and QAO — Tina Clemmey	Project File
Photographs (if allowable)	FTL — TBD	PM — Alexandra Stark	Project File
Correspondence	FTL — TBD	PM — Alexandra Stark	Project File
Equipment calibration logs	FTL — TBD	QAO — Tina Clemmey	Project File
Equipment maintenance, testing, and inspection logs	FTL — TBD	QAO — Tina Clemmey	Project File
Waste disposal records	FTL — TBD	PM — Alexandra Stark	Project File

Project Assessments			
Record	**Generation**	**Verification**	**Data Assessment Documents and Records**
Field audit checklists	FTL — TBD	PM — Alexandra Stark	Project File
Data verification checklists	Data Validator — Tina Clemmey	QAO — Tina Clemmey	Project File
Data validation report	Data Validator — Tina Clemmey	QAO — Tina Clemmey	Project File
Data usability assessment report	Data Validator — Tina Clemmey	PM — Alexandra Stark	Project File

Analytical Results Documents and Records			
Record	**Generation**	**Verification**	**Data Assessment Documents and Records**
Data verification checklists	Data Validator — Tina Clemmey	QAO — Tina Clemmey	Project File
Data validation report	Data Validator — Tina Clemmey	QAO — Tina Clemmey	Project File
Data usability assessment report	Data Validator — Tina Clemmey	QAO — Tina Clemmey	Project File

Laboratory Records			
Record	**Generation**	**Verification (Data Validation)**	**Data Assessment Documents and Records**
Sample receipt/log-in forms	Pace Analytical Services, LLC PM Lea Sherman	QAO — Tina Clemmey	Analytical results, documents, and records will be provided by the laboratory in printed and electronic formats. Although available in the Administrative Record file, laboratory reports are typically filed at a separate location and are available upon request. The records will be transferred after completion of a response action and, when 50 years old, will be destroyed. Electronic analytical results will also be verified, entered, and maintained in a database on a password-protected Structured Query Language (SQL) server. Data qualifiers will be added to the database during data validation. After validation, the validated data files will be transferred to an approved data management system.
Sample extraction logs	Pace Analytical Services, LLC PM Lea Sherman	Data Validator — Tina Clemmey	
Equipment calibration logs	Pace Analytical Services, LLC PM Lea Sherman	Data Validator — Tina Clemmey	
Sample preparation logs	Pace Analytical Services, LLC PM Lea Sherman	Data Validator — Tina Clemmey	
Sample analysis run logs	Pace Analytical Services, LLC PM Lea Sherman	Data Validator — Tina Clemmey	
Equipment maintenance, testing, and inspection logs	Pace Analytical Services, LLC PM Lea Sherman	Data Validator — Tina Clemmey	
Analytical discrepancy forms	Pace Analytical Services, LLC PM Lea Sherman	Data Validator — Tina Clemmey	
Reported field sample results	Pace Analytical Services, LLC PM Lea Sherman	Data Validator — Tina Clemmey	
Reported results for standards, quality control samples	Pace Analytical Services, LLC PM Lea Sherman	Data Validator — Tina Clemmey	
Data completeness checklists	Pace Analytical Services, LLC PM Lea Sherman	Data Validator — Tina Clemmey	
Data validation memoranda	Data Validator — Tina Clemmey	QAO — Tina Clemmey	

Laboratory Data Deliverables						
Record	**VOCs**	**1,4-Dioxane**	**Metals (total and dissolved)**	**Ferrous Iron**	**Total Hardness**	**Alkalinity**
Narrative	X	X	X	X	X	X
COC	X	X	X	X	X	X
Summary Results	X	X	X	X	X	X
QC Results	X	X	X	X	X	X
Chromatograms	X	X	X	NA	NA	NA

Notes:
TBD = to be determined
PM = project manager
FTL = field team leader
QAO = quality assurance officer
VOCs = volatile organic compounds
NA = not applicable
COC = Chain-of-Custody

QAPP WORKSHEETS #31, #32, and #33: ASSESSMENTS AND CORRECTIVE ACTION(S)

(UFP-QAPP Manual Sections 4.1.1 and 4.1.2)

PLANNED PROJECT ASSESSMENTS

Assessment Type	Responsible Party and Organization for Performing Assessment	Number/Frequency	Estimated Dates	Assessment Deliverable	Person(s) Responsible for Responding to Assessment Findings	Deliverable Due Date
Operational Readiness Review	FTL — TBD	Once — prior to field activities	TBD	Readiness review checklist/form	PM — Alexandra Stark	24 hours following completion of assessment
Laboratory Systems Audit	NELAP Auditor	Every 18 months	Specified by NELAP-accrediting Authorities	Laboratory systems audit checklist	Laboratory QAO	Specified by NELAP-accrediting Authorities
Field Sampling Systems Audit	QAO/Project Chemist, Tina Clemmey	Randomly selected program-wide by the project manager and may or may not include this project	TBD	Checklist including examinations of field sampling and measurement records, field instrument operating and calibration records, sample collection, handling and packaging in compliance with the established procedures, maintenance of QC procedures, COC, field and sample documentation, safety procedures	FTL — TBD or designee	48 hours following completion of assessment
Work Product Review	Technical Experts and Technical Editors	Draft, Draft Final, and Final Documents	TBD	Product review checklist	PM — Alexandra Stark	TBD
Data Validation	Data Validator —Tina Clemmey	Report per data package	Within 2 weeks of receipt of laboratory data	A report that review data completeness, laboratory precision, and overall data quality	QAO/Project Chemist, Tina Clemmey	2 weeks following receipt of laboratory data
Laboratory Quality Assurance Report	Pace Analytical Services, LLC — PM — Lea Sherman	When significant plan deviations result from unanticipated circumstances	Immediately upon detection of problem (on the same day)	A corrective action report that document significant plan deviations result from unanticipated circumstances and corrective actions taken to eliminate future occurrences	QAO/Project Chemist, Tina Clemmey	24 hours following completion of assessment

ASSESSMENT RESPONSE CORRECTIVE ACTION

Assessment Type	Responsible Party & Organization	Assessment Response Documentation	Time Frame for Response	Responsibility for Implementing Corrective Action	Responsible for Monitoring Corrective Action Implementation
Operational Readiness Review	FTL — TBD	Corrective action responses documented on checklist/form and/or in email/memorandum	24 hours following receipt of checklist/form	PM — Alexandra Stark	QAO — Tina Clemmey
Field Audit	FTL — TBD	Corrective action responses documented on checklist/report and/or in email/memorandum	24 hours following receipt of checklist/report	FTL — TBD	QAO — Tina Clemmey
Laboratory Audit	Pace Analytical Services, LLC — PM — Lea Sherman	Corrective action responses documented on checklist/report and/or in email/memorandum	48 hours following receipt of checklist/report	Pace Analytical Services, LLC — PM — Lea Sherman	QAO — Tina Clemmey
Work Product Quality Review	Technical Experts and Technical Editors	Corrective action responses documented in email/memorandum	48 hours following receipt of email/ memorandum	PM — Alexandra Stark	QAO — Tina Clemmey

Notes:

FTL = field team leader
TBD = to be determined
PM = project manager
NELAP = National Environmental Laboratory Accreditation
QAO = quality assurance officer
QC = quality control
COC = chain of custody

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QAPP WORKSHEET #34: DATA VERIFICATION AND VALIDATION INPUTS

(UFP-QAPP Manual Section 5.2.1)

Item	Description	Verification (Completeness)	Validation (Conformance to Specifications)	Usability (Achievement of DQOs)
Planning Documents/Records				
1	Approved QAPP	X		
2	Contract	X		
3	Field Standard Operating Procedures	X		
4	Laboratory Standard Operating Procedures	X		X
5	Laboratory Quality Assurance Manual	X		X
6	Laboratory Certifications	X		X
Field Records				
7	Field Logbooks	X		
8	Equipment Calibration Records	X		
9	Chain-of-Custody Forms	X	X	
10	Sampling Diagrams/Surveys	X		
11	Relevant Correspondence	X	X	
12	Change Orders/Deviations	X	X	X
13	Field Audit Reports	X		
14	Field Corrective Action Reports	X	X	
15	Sample Location Verification	X	X	
Analytical Data Package				
16	Cover Sheet (laboratory-identifying information)	X	X	X
17	Case Narrative	X	X	X
18	Internal Laboratory Chain-of-Custody	X	X	X
19	Sample Receipt Records	X	X	X
20	Sample Chronology (e.g., dates and times of receipt, preparation, & analysis)	X	X	X
21	Communication Records	X	X	X
22	LOD/LOQ Establishment and Verification	X	X	X
23	Standards Traceability	X	X	X
24	Instrument Calibration Records	X	X	X
25	Definition of Laboratory Qualifiers	X	X	X
26	Results Reporting Forms	X	X	X
27	Quality Control Sample Results	X	X	X
28	Corrective Action Reports	X	X	X
29	Raw Data	X	X	X
30	Electronic Data Deliverable	X	X	X

Notes:
DQO = data quality objectives
QAPP = Quality Assurance Project Plan
LOD = limit of detection
LOQ = limit of quantitation

QAPP WORKSHEET #35: DATA VERIFICATION PROCEDURES

Records Reviewed	Requirement Documents	Process Description	Responsible Person for Verification
Approved QAPP	QAPP, Contract	Verify completeness, correctness, and contractual compliance of all project QA/QC and data against the methods, SOPS, and contract requirements	PM — Alexandra Stark QAO — Tina Clemmey
Chain-of-custody forms Sample Login/Receipt	QAPP, Field SOPs, Laboratory SOPs	Review the sample shipment for completeness, integrity, and sign accepting the shipment All sample labels will be checked against the chain-of-custody form, and any discrepancies will be identified, investigated, and corrected. The samples will be logged in at every storage area and workstation required by the designated analyses. Individual analysts will verify the completeness and accuracy of the data recorded on the forms. Verification of sample login/receipt and chain-of-custody forms will be documented on the laboratory sample receipt form. Check that the chain-of-custody form was signed/dated by the sampler relinquishing the samples, and by the laboratory sample custodian receiving the samples for analyses Verification of chain-of-custody forms will be documented in the DVA workbook	Pace Analytical Services, LLC — PM — Lea Sherman QAO/Project Chemist — Tina Clemmey
QAPP sample tables	QAPP	Verify that all proposed samples listed in the QAPP tables have been collected Sample completeness will be documented in the data validation report	Daily: FTL — TBD and PM — Alexandra Stark At conclusion of field activities: QAO/Project Chemist — Tina Clemmey
Sample log sheets and field notes	QAPP, Field SOPs, Field Logbooks	Verify that information recorded in the log sheets and field notes are accurate and complete Sample log sheet verification will be documented by dated signature on the last page or page immediately following the review material	Daily: FTL — TBD and PM — Alexandra Stark At conclusion of field activities: QAO/Project Chemist — Tina Clemmey
Field QC samples	QAPP	Check that field QC samples, described in Worksheet #12 and listed in Worksheet #20, were collected as required QC sample completeness will be documented in the data validation report	FTL — TBD and PM — Alexandra Stark
Analytical data package	QAPP	Verify all analytical data packages will be verified internally for completeness by the laboratory performing the work The laboratory project manager (or designee) will sign the case narrative for each data package. All laboratory data package reviews will be documented in the laboratory narratives.	Pace Analytical Services, LLC — PM — Lea Sherman QAO/Project Chemist —Tina Clemmey

Records Reviewed	Requirement Documents	Process Description	Responsible Person for Verification
Analytical data package	QAPP	Verify the data package for completeness Missing information will be requested from the laboratory and validation will be suspended until missing data are received Data package completeness will be documented in the in the data validation report	QAO/Project Chemist — Tina Clemmey
Electronic data deliverables	QAPP	Verify the electronic data against the chain-of-custody and hard copy data package for accuracy and completeness before loading into project database Electronic data deliverable verification will be documented in the in the data validation report	QAO/Project Chemist — Tina Clemmey

Notes:

QAPP = Quality Assurance Project Plan
QA/QC = quality assurance/quality control
SOP = standard operating procedure
PM = project manager
QAO = quality assurance officer
FTL = field team leader
QC = quality control

QAPP WORKSHEETS #36: DATA VALIDATION PROCEDURES

Data Validator: EnSafe

Analytical Group/Method	VOCs/(8260C)	Metals/(6010)	1,4 dioxane/(Method 522)
Data Deliverable Requirements	Level 3 CLP data package plus chromatograms (PDF) hard copy and NYSDEC EQuIS EDDs	Level 3 CLP data package plus chromatograms (PDF) hard copy and NYSDEC EQuIS EDDs	Level 3 CLP data package plus chromatograms (PDF) hard copy and NYSDEC EQuIS EDDs
Analytical Specifications/Measurement Performance Criteria	Worksheets #12, #15, #24, and #28	Worksheets #12, #15, #24, and #28	Worksheets #12, #15, #24, and #28
Percent of Data Packages to be Validated	100%	100%	100%
Percent of Raw Data Reviewed	10%	10%	10%
Percent of Results to be Recalculated	10%	10%	10%
Validation Procedure	*National Functional Guidelines for Organic Superfund Methods Data Review* (U.S. EPA November 2020)	*National Functional Guidelines for Organic Superfund Methods Data Review* (U.S. EPA November 2020)	*National Functional Guidelines for Organic Superfund Methods Data Review* (U.S. EPA November 2020)
Percent of Data to be Validated	During validation, 90% of the data will undergo verification and U.S. EPA Stage 2B electronic and manual validation. Validation will be limited to reviewing laboratory quality control summary information and raw data will not be reviewed. 10% of the data will undergo verification and U.S. EPA Stage 3 electronic and manual validation and raw data will be reviewed.		
Validation Code	S2VEM (90%) and S3VEM (10%)	S2VEM (90%) and S3VEM (10%)	S2VEM (90%) and S3VEM (10%)
Electronic Validation Program/Version	EQuIS	EQuIS	EQuIS
Validation Data Qualifiers	Qualifiers that will be applied during the data validation process are summarized below and, as indicated, results will be considered usable for interpretation. Use of data with serious deficiencies will be decided by the project team.		

Data Qualifier	Qualifier Definition	Interpret Result as a Detection?	Result Usable?	Potential Result Bias
No qualifier	Acceptable	Yes	Yes	None expected
J	Estimated	Yes	Yes	High or Low
J+	Estimated biased high	Yes	Yes	High
J-	Estimated biased low	Yes	Yes	Low
U	Undetected	No	Yes	None expected
UJ	Undetected and Estimated	No	Yes	High or Low
X	Exclusion of data is recommended	No	No	Unspecified

Notes:
VOCs = Volatile Organic Compounds
CLP = Contract Laboratory Program
PDF = portable document format
EDD = Electronic Data Deliverable
U.S. EPA = United States Environmental Protection Agency

QAPP WORKSHEETS #37: DATA ASSESSMENT

Personnel responsible for participating in the data usability assessment will include the Project Chemist/QAO, PM, and Technical Lead who will be responsible for conducting the listed data usability assessments. The data usability assessment will include the elements provided in Table 37-1.

Table 37-1
Data Assessment Process

Step 1	**Review Project Objectives and Sampling Design** *Review key outputs defined during systematic planning (e.g., DQOs, and MPCs) to make sure they are still applicable. Review the sampling design for consistency with stated objectives. This provides the context for interpreting the data in subsequent steps.*
Step 2	**Review Data Verification and Data Validation Outputs** *Review available QA reports, including data verification and validation reports. Perform basic calculations and summarize the data (using graphs, maps, tables, etc.). Look for patterns, trends, and anomalies (i.e., unexpected results). Review deviations from planned activities (e.g., number and locations of samples, holding time exceedances, damaged samples, and SOP deviations) and determine their impacts on data usability. Evaluate implications of unacceptable QC sample results.*
Step 3	**Verify Assumptions of Selected Statistical Method** *Verify whether underlying assumptions for selected statistical method(s) are valid. Depending on the robustness of the statistical method, minor deviations from assumptions usually are not critical to statistical analysis and data interpretation. If serious deviations from assumptions are discovered, then another statistical method may need to be used.*
Step 4	**Implement the Statistical Method** *Implement the selected statistical procedures for analyzing the data and review underlying assumptions. For decisions that involve hypothesis testing, consider the consequences for selecting the incorrect alternative; for decisions that involve estimation, consider the tolerance for uncertainty in measurements.*
Step 5	**Document Data Usability and Draw Conclusions** *Determine if the data can be used as intended, considering implications of deviations and corrective actions. Discuss data quality indicators. Assess the performance of the sampling design and identify limitations on data use. Update the conceptual site model and document conclusions. Prepare a data usability summary report.*

Notes:
DQO = data quality objectives
MPC = Measurement Performance Criteria
QA = quality assurance
SOP = Standard Operating Procedure
QC = quality control

The quality and usability of data obtained during the project will be determined by examining data review/verification/validation summary reports and verifying that the sampling procedures and analytical results were obtained following the applicable protocols, that they are of sufficient quality to satisfy DQOs, and that they can be relied upon for their intended use. This evaluation will include checking field logbooks/forms, field procedures, analyses requested versus analyses performed, data review/verification/validation summary reports, and other QC information. The data assessment will determine possible effects on the data that result from project requirement failures (e.g., data quality), and their actual adequacy to fulfill the Site-specific QA/QC requirements (i.e., data usability).

Project-specific and/or event-specific DQOs/Measurement Performance Criteria will be compared to the data results from the particular field program event to determine if the requirements were

achieved. Efforts to evaluate and verify attainment of PSQ/DQO statements will enable data users to understand any usability limitations associated with project data. Procedures used to assess project objectives will be in accordance with the appropriate analytical methods, which were original selected based on their ability to meet project goals.

Data qualified as estimated during validation will be utilized during project decisions and reporting, provided that the data meet other project-specific DQOs. Data deemed unusable (i.e., rejected) after validation review will not be used to make project decisions.

When unusually high analytical results are obtained, the results will be evaluated to determine if the results are legitimate or outliers. If an isolated high result is obtained in a location shown to have lower concentrations of the detected constituent, then the result may be considered an outlier; however, depending on the intended use of the data, re-sampling may be required to verify the value and/or the sample containing this elevated result may undergo re-analysis to check for analytical error or homogeneity issues. Statistical calculations may be used to determine whether a result is a statistical anomaly.

Calculations to be performed during the data quality/usability and DQO reconciliation include RPD for field duplicate sample pairs, percent of QC sample results that were considered "acceptable" in regard to DQOs (e.g., what percent of the offsite laboratory analytical results were associated with precision samples that were within their prescribed limits), and percent complete for project (and as applicable, for specific matrices or fractions).

Appendix A
Personnel Training / Certification Documentation

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January 12, 2015

Mr. Brian E. Caldwell
PO Box 576
Louisville, TN 37777

Dear Mr. Caldwell:

It is a pleasure to welcome you back into the American Institute of Professional Geologists. Your former Certified Professional Geologist number, CPG-09381, is reassigned to you as part of this reinstatement.

The Institute is determined to increase awareness of the geologic profession, both with the general public and our elected representatives. The AIPG needs to attract as many professionals as possible to its ranks in order to have an impact on legislation and your return to the Institute will make a difference.

I hope you will be actively involved in your Section's activities during the coming year. The Institute will be moving in several new directions this year, and we believe you will find increased rewards and benefits from your membership. We also hope you will participate in helping the Institute find even more ways to serve its Members.

AIPG and the geologic profession need the efforts and abilities of people like you. We are pleased to reinstate your Institute Membership.

Very truly yours,

J. Foster Sawyer
President

f: Mbr file

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Appendix B
Laboratory Accreditation Certificate

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Appendix C
Laboratory Standard Operating Procedures

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Appendix D
Field Standard Operating Procedures

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Standard Operating Procedure
Sample Labeling and Chain-of-Custody

These standards will ensure continuity within the organization.

Preamble

This standard operating procedure (SOP) is designed to provide the user with procedures on how to label environmental samples and document sample information on a chain-of-custody form.

1.0 SCOPE AND APPLICABILITY

The purpose of this standard operating procedure is to establish standard protocols for all field personnel for use in maintaining field and sampling activity records, labeling samples, ensuring that proper sample custody procedures are utilized, and completing chain-of-custody/analytical request forms. If there are procedures from a client, state and/or federal that are not addressed in this SOP and are applicable to sample handling, storage, and shipping then those procedures may be added as an appendix to the project specific Plan.

1.1 Definitions

Chain-of-custody — Chain-of-custody (COC) is documentation of the process of custody control. Custody control includes possession of a sample from the time of its collection in the field to its receipt by the analytical laboratory, and through analysis and storage prior to disposal.

QC — Quality control

MS/MSDs — matrix spike/matrix spike duplicates

Shall or *must* — When these words are associated with a procedure or other item, the item is mandatory and expected to be performed in all cases. Deviations from the SOP containing these words shall be documented.

Should or *may* — When these words are used, the referenced item is recommended or suggested, but not mandatory.

1.2 Related SOPs

SOP FD-01-00 Field Documentation

1.3 Personnel Qualifications

This procedure will be implemented by professionals who, through prior training and/or experience, are knowledgeable about the procedures for identification of environmental samples.

2.0 PROCEDURES

This procedure provides standards for labeling samples, documenting sample custody, and completing COC/analytical request forms. The standards presented in this section shall be followed to ensure that samples collected are maintained for their intended purpose and that the conditions encountered during field activities are documented.

2.1 Sample Labeling

Affix a waterproof sample label with adhesive backing to each individual sample container. Record the following information with a waterproof marker on each label:

- Project name or number
- COC sample number
- Date and time of collection
- Sampler's initials
- Matrix
- Sample preservatives (if applicable)
- Analysis to be performed on sample (This shall be identified by the method number or name identified in the subcontract with the laboratory)

These labels may be obtained from the analytical laboratory or printed from a computer file onto adhesive labels.

2.2 Custody Procedures

For samples intended for chemical analysis, sample custody procedures shall be followed through collection, transfer, analysis, and disposal to ensure that the integrity of the samples is maintained. A description of sample custody procedures is provided below.

Sample Collection Custody Procedures

According to the U.S. EPA guidelines, a sample is considered to be in custody if one of the following conditions is met:

- It is in one's actual physical possession or view
- It is in one's physical possession and has not been tampered with (i.e., it is under lock or official seal)
- It is retained in a secured area with restricted access
- It is placed in a container and secured with an official seal such that the sample cannot be reached without breaking the seal

Place custody seals on shipping coolers (and sample jars, if required) if the cooler/container is to be removed from the sampler's custody. Place a minimum of two custody seals in such a manner that they must be broken to open the containers or coolers. Label the custody seals with the following information:

- Sampler's name or initials
- Date and time that the sample/cooler was sealed

These seals are designed to enable detection of sample tampering. An example of a custody seal is shown in Attachment 1.

Field personnel shall also log individual samples onto COC forms (carbon copy or computer generated)

when a sample is collected. These forms may also serve as the request for analyses. Procedures for completing these forms are discussed in Section 3.3, indicating sample identification number, matrix, date and time of collection, number of containers, analytical methods to be performed on the sample, and preservatives added (if any). The samplers will also sign the COC form signifying that they were the personnel who collected the samples. The COC form shall accompany the samples from the field to the laboratory. When a cooler is ready for shipment to the analytical laboratory, the person delivering the samples for transport will sign and indicate the date and time on the accompanying COC form. One copy of the COC form will be retained by the sampler and the remaining copies of the COC form shall be placed inside a self-sealing bag and taped to the inside of the cooler. Each cooler must be associated with a unique COC form. Whenever a transfer of custody takes place, both parties shall sign and date the accompanying carbon copy COC forms, and the individual relinquishing the samples shall retain a copy of each form. One exception is when the samples are shipped; the delivery service personnel will not sign or receive a copy because they do not open the coolers. The laboratory shall attach copies of the completed COC forms to the reports containing the results of the analytical tests. An example COC form is provided in Attachment 2.

2.3 Completing COC/Analytical Request Forms

COC and analytical request form completion procedures are crucial in properly transferring the custody and responsibility of samples from field personnel to the laboratory. This form is important for accurately and concisely requesting analyses for each sample; it is essentially a release order from the analysis subcontract.

Attachment 2 provides a COC and analytical request form that may be used by field personnel, with box numbers identified and discussed in text below. Multiple copies may be tailored to each project so that much of the information described below need not be handwritten each time. Each record on the form (Attachment 2) is identified with a bold number corresponding to the instructions given below.

1. Record the project name.

2. Record the site location, including the state.

3. Record the person(s) that should receive the laboratory data.

4. Record the COC number that is defined by the sampler and should be unique throughout the project's history. An example would be to use the sampler's initials followed by the date. If multiple custodies are generated on a given day, use a unique sequential identifier. Example: CRC040105A, CRC040105B.

5. Record the purchase order number provided by EnSafe's purchasing department.

6. Record the page and total number of COC forms used in a shipment.

7. Record the project, phase, and task number applicable to the sampling task.

8. Record the sampler(s) name.

9. Record the laboratory name where the samples were sent.

10. Record the requested turnaround time, in days. If a specific turnaround time is required to meet project objectives but was not indicated on the laboratory service request form submitted to the EnSafe purchasing department, the sampler, project manager, or site manager should contact the purchasing department, so the laboratory contract can be modified.

11. Record the two-character code corresponding to the *chemical* preservation type, which is found on the bottom of the COC form. If no chemical preservation was added to the sample, the field should be left blank. Temperature preservation need not be documented at this location but will be indicated elsewhere on the COC form.

12. List the requested analysis. Whenever possible, list the corresponding analytical method. (e.g., VOCs, 8260).

13. Record the sample identification. Field duplicate samples will use the same example sample ID as the parent sample but will be differentiated by the sample type (see 20).

14. Record the location identification, which is a shortened ID used for presentation and mapping.

15. Record the sample date using the format month, day, year (mm/dd/yy).

16. Record the sample time using the military format of hours and minutes (hh:mm).

17. Record the matrix code of the sample, which is located at the bottom of the COC form. The matrix code is a crucial element of an electronic data management system. For simplicity, only typical matrix codes are listed on the bottom COC form, but below is a complete listing of all applicable matrix codes:

Matrix Codes			
Matrix Code	**Matrix Code Description**	**Matrix Code**	**Matrix Code Description**
AA	Ambient Air	SM	Water Filter (Solid Material used to filter Water)
AD	Drilling Air	SN	Miscellaneous Solid Materials — Building Materials
AE	Air, Vapor Extraction Well Effluent	SO	Soil
AQ	Air Quality Control Matrix	SP	Casing (PVC, Stainless Steel, Cast Iron, etc.)
CA	Cinder-Ash	SQ	Soil/Solid Quality Control Matrix
CF	Fly Ash Cinder	SR	Water Filter Residue (Solid filtered out of Water)
DC	Drill Cuttings	SS	Scrapings
GE	Gaseous Effluent (Stack Gas)	ST	Solid Waste
GL	Headspace of Liquid Sample	SW	Swab or Wipe
GS	Soil Gas	TA	Animal Tissue
LA	Aqueous Phase of a Multiple Phase Liquid or Solid Sample	TP	Plant Tissue
LC	Liquid Condensate	TQ	Tissue Quality Control Matrix
LD	Drilling Fluid	U	Unknown
LE	Liquid Emulsion	W	Water

Matrix Codes			
Matrix Code	**Matrix Code Description**	**Matrix Code**	**Matrix Code Description**
LF	Floating/Free Product on Groundwater Table	WA	Drill Cuttings, Aqueous Matrix
LH	Liquid Waste Containing < 0.5% Dry Solids	WC	Drilling Water (Used for Well Construction)
LM	Multiple Phase Liquid Waste Sample	WD	Well Development Water
LO	Organic Liquid	WE	Estuary
LV	Liquid from Vadose Zone	WG	Ground Water
MH	Hazardous Multiple Phase Waste	WH	Equipment Wash Water, i.e., used for Washing
Oil	Oil	WL	Leachate
SB	Bentonite	WO	Ocean Water
SC	Cement	WP	Drinking Water
SD	Drill Cuttings, Solid Matrix	WQ	Water Quality Control Matrix
SE	Sediment (Associated with Surface Water)	WS	Surface Water
SF	Filter Sandpack	WV	Water from Vadose Zone
SH	Solid Waste Containing ± 0.5% Dry Solids	WW	Waste Water
SL	Sludge	WZ	Special Water Quality Control Matrix

18. Record the sample type code, which is located at the bottom of the COC form. The sample type is a crucial element of an electronic data management system. For simplicity, only typical sample type codes are listed on the bottom of the COC form, but below is a list of all applicable field sample type codes:

Sample Type Codes	
Sample Type Code	**Sample Type Code Description**
AB	Ambient Conditions Blank
EB	Equipment Blank
FB	Field Blank
FD	Field Duplicate Sample
FR	Field Replicate
FS	Field Spike
KD	Known (External Reference Material) Duplicate
MB	Material Blank
N	Normal Environmental Sample
RB	Material Rinse Blank
RD	Regulatory Duplicate
RM	Known (External Reference Material) Rinsate
TB	Trip Blank

Field QC blanks will require matrix codes that identify the type of blank associated with parent sample. Aqueous field QC blanks are not automatically identified with a matrix code of "WQ," indicating a water quality control blank; they are only identified with a matrix code of "WQ" if the associated samples are also aqueous. Trip blanks, field blanks, and equipment rinsate blanks collected in association with ***soil*** samples will be identified with a matrix code of "SQ," even though the actual matrix is aqueous, because the blanks were collected to assess potential contamination imparted during decontamination activities or transport of ***soil*** samples.

Field duplicates will be identified using the format detailed in the Site's Plan. However, field duplicates will also be differentiated from the parent sample on the chain-of-custody form. The parent sample will have a sample type code of "N," for normal environmental sample; while its duplicate will have a sample type code of "FD."

19. Record whether the sample is field filtered with a "Y" or not field filtered with an "N." If a project requires collecting samples for both total and dissolved constituents, the same sample and location ID is used for both (see 15 and 16); however, the sampler will indicate whether the sample is field filtered at this location on the COC form. This field must always be filled out; even when soil samples are collected (where "N" appropriately applies, in most cases).

20. Record the total number of containers that are submitted for all of the tests. This must add up to the total number of containers listed for each individual test in 23.

21. Record the number of containers for each test. Do not use Xs, rather indicate the number of containers submitted for each test listed in 14. For example, Sample 010MW007002 requires analysis for VOCs (8260), and SVOCs (8270). Record 4 under the VOC analysis and 2 under the SVOC (assuming 4 containers were submitted for VOCs and 2 were submitted for SVOCs). The total number of containers in this example is 6, which should be the total number of containers listed in 22. Extra containers submitted for matrix spike/matrix spike duplicates (MS/MSDs) will be appropriately recorded.

22. Indicate if extra sample volume was included for MS/MSD analysis with a "X". Samples to be used for MS/MSDs will use the same sample ID and location ID but will be collected in triplicate to ensure the analytical laboratory receives sufficient volume for the analyses.

23. Indicate if the sample is to be held by the laboratory until instructed otherwise with a "X".

24. Record any field comments.

25. Reserved for laboratory comments.

26. Indicate the total number of coolers in each shipment. *Note*: When multiple coolers are submitted, each should contain a COC form.

27. Signature(s) of the person(s) relinquishing sample custody.

28. Signature(s) of the person(s) receiving sample custody.

29. Indicate whether the samples are iced, by checking the appropriate response.

30. Indicate the method of shipment (e.g., priority overnight courier, hand-delivered, laboratory courier).

31. Record the airbill number when a commercial courier is used. This is particularly important when multiple coolers are sent in the same shipment or when the laboratory is sent the COC form in advance of receiving samples because it aids in tracking lost coolers.

32. Record the date the cooler(s) were shipped.

3.0 DATA/RECORDS MANAGEMENT

Data will be recorded promptly, legibly, and in indelible ink on the COC form. Completed logbooks and forms will be submitted to and maintained by the project manager (or designee) after completion of the activity.

4.0 QUALITY CONTROL AND QUALITY ASSURANCE

The COC form is crucial in ensuring that all of the required information is transmitted to the laboratory, so they can properly populate required fields in its electronic data submission. The sample ID system requires planning on the part of the project or site manager to ensure that every sample has a *unique* number. Likewise, standardized and consistent matrix codes and sample types, described in this SOP, must used to ensure sample IDs are properly handled in the electronic data management system.

The project or site manager should be involved in sample ID, matrix code, and sample type planning and should inform samplers of the site's sample ID design. The project/site manager should also perform periodic checks to ensure sample ID consistency. He/she should also request that the laboratory provide sample log-in forms to ensure the laboratory entered information documented on the COC form correctly into its system prior to analysis. These checks on the front end will save time before data is loaded and will expedite data interpretation with minimum corrections.

5.0 NONCONFORMANCE AND CORRECTIVE ACTION

Any deviations from the standard protocol or any problems that occur during procedure implementation must be documented in the logbook or forms and corrective action should be applied, if warranted.

6.0 REFERENCES (None)

7.0 FORMS AND DATA SHEETS

Attachment 1 — Example Chain-of-Custody Seal
Attachment 2 — Generic Chain-of-Custody and Analytical Request Form

Author	Reviewer	Revisions (Technical or Editorial)
Tina Cantwell	Allison Harris	Revision 0 – May 2006 (Initial Issue)
Tina Cantwell	Tom Deck	Revision 1 – July 2019 (Editorial/Re-format)

Attachment 1
Example Chain-of-Custody Seal

EXAMPLE CHAIN-OF-CUSTODY SEAL

ENSAFE	SAMPLE NO.	DATE	SEAL BROKEN BY
	SIGNATURE		DATE
	PRINT NAME		

Attachment 2
Example Chain-of-Custody / Analytical Request Form

ENSAFE

EnSafe Inc.
800-588-7962

CHAIN OF CUSTODY AND ANALYTICAL REQUEST RECORD

Chain of Custody No. 4 | Page 6 of

Project Name: 1 | PO No. 5 | Project No. 7 | Phase

Site Location: 2 | **Sample Analysis Requested** (Enter containers for each test)

Send Results To: 3

Sampler/Site Phone# 8

Lab Name: 9 | Turnaround Time(specify): 10

Lab ID	Sample ID (sys_samp_code)	Location ID (sys_loc_code)	Date (mm/dd/yy)	Time (Military) (hhmm)	Matrix Code **(1)**	Sample Type **(2)**	Field Filtered (Y/N)	Total No. of Containers	(3)➔								Extra Volume for MS/MSD	HOLD
	13	14	15	16	17	18	19	20	11								22	23
									12									

***Field* Comments:** 24

***Lab* Comments:** 25

Sample Shipment and Delivery Details
Number of coolers in shipment: 26

Relinquished by (signature)	Date	Time	Received by (signature)	Date	Time
1 27			1 28		
2			2		
3			3		

Samples Iced?(check) Yes 29___ No_____

Method of Shipment: 30

Airbill No: 31

Date Shipped: 32

(1) AA=Ambient air, **AQ**=Air quality control, **ASB**=Asbestos, **CK**=Caulk, **DS**=Storm drain sediment, **GS**=Soil gas, **IC**=IDW Concrete, **IDD**=IDW Solid, **IDS**=IDW soil, **IDW**=IDW Water, **LF**=Free Product, **MA**=Mastic, **PC**=Paint Chips, **SC**=Cement/Concrete, **SE**=Sediment, **SL**=Sludge, **SO**=Soil, **SQ**=Soil/Solid quality control, **SSD**=Subsurface sediment, **SU**=Surface soil (<6 in), **SW**=Swab or wipe, **TA**=Animal tissue, **TP**=Plant tissue, **TQ**=Tissue quality control, **WG**=Ground water, **WL**=Leachate, **WO**=Ocean water, **WP**=Drinking water, **WQ**=Water quality control, **WR**=Ground water effluent, **WS**=Surface water, **WU**=Storm water, **WW**=Waste water

(2) Sample Type: AB=Ambient Blk, **EB**=Equipment Blk, **FB**=Field Blk, **FD**=Field Duplicate Sample, **IDW**=Investigative-Derived Waste, **MIS**=Incremental Sampling Methodology, **N**=Normal Environmental Sample, **TB**=Trip Blk

(3) Preservative added: **HA**=Hydrochloric Acid, **NI**=Nitric Acid, **SH**=Sodium Hydroxide, **SA**=Sulfuric Acid, **ME**=Methanol, **SB**=sodium bisulfate, **ST**=Sodium Thiosulfate, If **NO preservative** added leave blank

Rev 7/19

Standard Operating Procedure
Decontamination of Sampling Equipment

These standards will ensure continuity within the organization.

Preamble

This standard operating procedure (SOP) represents EnSafe's minimum standard of practice for decontaminating field equipment. State and federal requirements may vary, as may project specific work plans, all of which must be consulted before work begins. This SOP may be modified to meet specific regulatory, client, or project specific criteria in accordance with Section 7.0.

1.0 SCOPE AND APPLICABILITY

The main objective of the decontamination Standard Operating Procedure (SOP) is to ensure that all equipment that may have contact with a sample during sample collection is free of contaminants and analytes that could impact study objectives. This overlaps with the main objective of the cleaning procedure, which is to ensure that equipment, before or after use, has been cleaned in such a manner that it is free of contaminants and will not impact current or future sampling or endanger individuals handling the equipment. If there are procedures from a client, state and/or federal agency that are not addressed in this SOP and are applicable to decontamination, those procedures may be added as an appendix to the project specific Plan.

1.1 Definitions

Sampling and Analysis Plan (SAP) — A plan that outlines the sampling procedures and protocols to be followed during a field effort.

Shall or *must* — when these words are associated with a procedure or other item, the item is mandatory and performance is expected in all cases. Deviations from the SOP containing these words shall be documented.

Should or *may* — when these words are used, the referenced item is recommended or suggested, but not mandatory.

Standard Operating Procedure (SOP) — A document that gives a step-by-step description of how a specific operation, method, or procedure is performed.

1.2 Related SOPs

FS-01-01	General Sampling	FS-09-01	Potable Water Supply Sampling
FS-02-01	Soil Sampling	FS-10-01	Contamination Surfaces Sampling
FS-03-01	Groundwater Sampling	FS-11-01	Waste and IDW Sampling
FS-04-01	Pore Water Sampling	FS-12-01	PFAS Sampling
FS-05-01	Diffusion Sampling	FS-14-01	Wastewater Sampling
FS-06-01	Sediment Sampling	FS-15-01	Tissue Sampling
FS-07-01	Soil Gas Survey	FQ-01-01	QA/QC Sampling
FS-08-01	Surface Water Sampling		

1.3 Health and Safety

Caution should be exercised and all applicable safety procedures shall be followed. For concerns regarding specific health and safety issues, see the site-specific health and safety plan, as well as SOP FT-01-00 General Field Testing.

- Safety glasses with splash shields or goggles, disposable gloves, and safety boots shall be worn during all decontamination operations. Additional PPE may be required per the site-specific SAP.

- No eating, smoking, drinking, chewing, or any hand to mouth contact shall be permitted during cleaning operations.

1.4 Cautions

Personnel shall inspect and familiarize themselves with all site-specific field equipment before entering the field. Care should be taken by personnel to protect themselves from inadvertent exposure to contaminated equipment received from a vendor or improperly decontaminated equipment received from a third party. Solvents, soap, and rinse waters used to clean equipment cannot be reused.

Personnel shall take appropriate precautions when handling, stowing, and/or transporting field equipment unless the equipment has been specifically identified as decontaminated or certified clean.

Decontaminated equipment shall only be handled by personnel wearing latex or nitrile gloves to prevent re-contamination.

1.5 Interferences

(None)

1.6 Personnel Qualifications

Personnel must be knowledgeable of the procedures in this SOP. Documentation of training and familiarization with this SOP can be found in the training file for each employee.

2.0 APPARATUS AND MATERIALS

Recommendations for the types of cleaning supplies are discussed in this section.

- *Soap* shall be a standard brand of phosphate-free laboratory detergent such as Liquinox. Use of another detergent must be justified and documented in the field logbooks, inspection, and/or investigative reports. Soap may be stored in its original container or in a high density polyethylene (HDPE) or polypropylene container. The soap should be poured directly from this container during use.

- *Solvent* shall be pesticide-grade isopropanol. Use of a solvent other than pesticide-grade isopropanol (i.e., acetone, methanol, etc.) must be specified in the site-specific SAP. Solvent shall be stored in its original container until used in the field. Solvents may be dispensed from glass, Teflon or stainless-steel containers. If a stainless steel device is used,

any gaskets that may contact the solvents must be constructed on inert material. Pesticide-grade isopropanol must be obtained from a laboratory supply vendor. Rubbing alcohol or other commonly available sources of isopropanol are not acceptable.

- *Tap Water* may be used from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water; however, bottled water (i.e., drinking water, distilled water, etc) is an acceptable substitute. Tap water may be kept in clean tanks, hand pressure sprayers, squeeze bottles, or applied directly from a hose.

- *Analyte-Free (Deionized) Water* is water that has been treated by passing through a standard deionizing resin column. At a minimum, the finished water should contain no detectable heavy metals or other inorganic compounds (i.e., at or above analytical detection limits). Deionized water must be stored in clean glass or Teflon containers that can be securely closed before and after use. The use of containers made of materials other than glass or Teflon must be specified in the approved site-specific SAP. Deionized water may be applied from a Teflon squeeze bottle.

- *Decontamination Pad* is an area designated and constructed for field cleaning of sampling and drilling equipment that is known or believed to be free of surface contamination. If possible, the pad should be constructed on a level, paved surface and should facilitate the removal of wastewater. Sawhorses or racks constructed to hold equipment while being cleaned should be high enough above ground to prevent equipment from being splashed. If a temporary pad is constructed, it should be lined with a water impermeable material (without seams) within the pad. This material should be easily replaced (disposable plastic Visqueen).

- *Cleaning Utensils* may include scrub pads, brushes, and buckets and may or may not be dedicated to a specific project. Projects requiring frequent sampling may dedicate cleaning utensils to this project to avoid any possibility of cross-contamination from another site. Color coding dedicated equipment and cleaning utensils will aid in site-specific identification.

- *Decontaminated Equipment Storage and Materials* may include aluminum foil, untreated butcher paper, clean (untreated) disposable plastic bags, or other untreated plastic wrap. Plastic bags shall not contact equipment to be used when volatile and extractable organics are potential contaminants of concern. Plastic bags may be used on equipment that has been wrapped with foil or butcher paper. Decontaminated equipment is wrapped to prevent recontamination. If the decontaminated equipment is to be stored for any period of time, the wrapping should include the date on which it was decontaminated.

3.0 PROCEDURES

The following procedures will be used for the decontamination of all sampling equipment. Any deviation from these procedures must be outlined in the site-specific SAP. All deviations from these procedures should be documented. Field personnel shall review the field decontamination requirements in the SAP prior to commencing field work activities.

When possible, clean equipment and materials should be transported to the field so that an entire study can be conducted without the need for field cleaning.

3.1 Instrument or Method Calibration

(Not Applicable)

3.2 Decontamination Procedures

The following procedures are to be used when sampling equipment is decontaminated. All sampling equipment must be decontaminated between sample locations and between sample intervals. At no time shall sampling equipment that has been in contact with contaminated or potentially contaminated media be used for sample collection without being properly decontaminated. These procedures should be used to decontaminate all sampling equipment constructed of stainless steel, carbon steel, Teflon, polyvinyl chloride (PVC), Acrylonitrile Butadiene Styrene (ABS), or other plastics. Equipment should be disassembled to the extent that access is gained to all surfaces that may contact contaminated media.

1. Clean with tap water and soap using a brush to remove all debris and surface films. Equipment may be steam cleaned (soap and high-pressure hot water) as an alternative to brushing. Sampling equipment that is steam cleaned should be placed on racks or saw horses at least 2 feet above the floor of the decontamination pad. Teflon, PVC, ABS, or other plastic items should not be steam cleaned.

2. Rinse thoroughly with tap water.

3. Rinse thoroughly with deionized water.

4. Rinse thoroughly with solvent if appropriate. Do not solvent rinse PVC or plastic items.

5. Rinse thoroughly with deionized water. If sufficient volumes of deionized water are not available, equipment should be allowed to completely air dry.

6. Remove the equipment from the decontamination area and wrap with aluminum foil, untreated butcher paper, or other acceptable material

3.2.1 Decontamination of Sample Tubing

Unless the manufacturer certifies tubing as clean, sample tubing will require decontamination before use. The tubing should be cut to appropriate lengths to accommodate the monitoring wells. Before decontaminating the tubing, check the tubing for discoloration and elasticity. Discard tubing that is discolored or has lost its elasticity.

Tubing Exterior

1. Decontaminate the exterior of the tubing by soaking in soapy water mixture. Use a brush to remove particulates if needed.

2. Rinse the exterior of the tubing with tap water.

Tubing Interior

1. Mix a solution of tap water and soap.

2. Connect one end of the tubing to the influent end of the pump.

3. Place other end of the tubing into the soapy water mixture and allow the pump to draw the water through the tubing. The soapy water mixture should pass through the entire length of the tubing prior to entering the pump. Recycle the effluent from the pump by connecting a length of tubing at the pump effluent to the soapy solution.

4. Place the other end of the tubing into tap water and allow the pump to draw the tap water through the tubing. The tap water volume should be twice the volume of the soapy water mixture.

5. Follow the same procedure described above to pump deionized water through the Teflon tubing except do not recycle the deionized water. The volume of deionized water should be equal to that of the tap water.

When possible, tubing should be dedicated to each groundwater monitoring well to eliminate the need for decontamination and possible cross-contamination. If dedicated sample tubing is stored for long periods of time, the tubing should be decontaminated before use.

3.2.2 Decontamination of Sampling Pumps

Sampling pumps pose unique problems. Pumps may require disassembly to gain access to all parts that come in contact with contaminated or potentially contaminated media.

Pump Exterior

1. Scrub with soapy water mixture using a brush to remove all debris and surface films
2. Rinse thoroughly with tap water
3. Rinse thoroughly with deionized water
4. Air dry

Pump Interior

If pump is used for purging and sampling, disassemble pump to gain access to all internal and external parts that may contact the sample media if possible. If the pump cannot be disassembled then the following procedures apply.

1. Pump several gallons of soapy water

2. Pump several gallons of tap water
3. Pump several gallons of deionized water

4. Remove the equipment from the decontamination area and wrap with aluminum foil or other acceptable material

3.2.3 Decontamination of Drilling Equipment

The following is the standard procedure for field cleaning augers, drill stems, rods, tools, and associated equipment:

1. Clean with tap water and soap, using a brush if necessary, to remove particulate matter and surface films. Steam cleaning (high-pressure hot water with soap) may be necessary to remove matter that is difficult to remove with the brush. Drilling equipment that is steam cleaned should be placed on racks or saw horses at least 2 feet above the floor of the decontamination pad. Hollow-stem augers, drill rods, etc., that are hollow or have holes that transmit water or drilling fluids should be cleaned on the inside with vigorous brushing if possible.

2. Rinse thoroughly with tap water. The site-specific SAP will identify if additional decontamination (i.e., alcohol rinse, deionized water rinse, etc.) is required.

3. Remove from the decontamination pad and cover with clean, unused plastic. If not used immediately, the plastic should be secured to ensure that it stays in place.

3.2.4 Decontamination of Field Instruments

Field instruments include water level indicators, interface probes, etc. Follow manufacturer's recommendations for cleaning instruments. The following procedures should be performed at a minimum:

1. Wash equipment body, probes and cables with soapy water mixture

2. Rinse thoroughly with tap water

3. Store equipment in accordance with manufacturer's specifications or wrap with aluminum foil

3.2.5 Decontamination of Field Analytical Instruments

Field analytical instruments include pH meters, DO meters, conductivity meters, etc. Follow manufacturer's recommendations for cleaning instruments. The following procedures should be performed at a minimum:

1. Wipe the exterior of the instrument with a clean, damp cloth
2. Rinse the probe with analyte free water
3. Air dry

Each time the instrument is cleaned, check for and replace any desiccant.

3.2.6 Decontamination of Ice Chests and Reusable Shipping Containers

1. Wash the interior and exterior of ice chests and reusable shipping containers with soapy water mixture

2. Rinse thoroughly with tap water

3. Air dry

If the container becomes severely contaminated with wastes, clean as thoroughly as possible, render unusable and properly dispose.

3.3 Disposal of Decontamination Fluids

The site SAP should specify how spent decontamination fluids will be handled and disposed of. Spent decontamination fluids may need to be treated as investigation-derived waste (IDW) and handled accordingly. If solvents are used in the decontamination process, the solvents shall be collected, labeled and stored separately for proper disposal. Personnel shall review the field decontamination and IDW handling requirements in the SAP before commencing field work activities.

4.0 DATA ACQUISITION, CALCULATIONS, AND DATA REDUCTION

(None)

5.0 DATA/RECORDS MANAGEMENT (None)

Document cleaning procedures described below for the indicated activities. See FD-01-00 for additional information about required records and retention of documents.

5.1 Field Equipment

In-Field Cleaning

1. Describe the procedures that are used to clean equipment
2. Record the date and time that equipment was cleaned

In-House Cleaning

1. Retain any cleaning certificates, whether from a laboratory or commercial vendor
2. Describe the procedure(s) that are used to clean equipment
3. Record the date that the equipment was cleaned

5.2 Sample Containers

1. Retain the packing slips, lot numbers of each shipment, any certification statements provided by the vendor and the vendor cleaning procedures for precleaned containers.

2. If containers are certified clean by the laboratory the laboratory must record:

- Type of container
- Date cleaned
- SOP used
- Person responsible for cleaning
- Lot number (date of cleaning may be used) of the batch of containers that were cleaned using the same reagent lots and the same procedure
- Results of quality control tests for the lot numbers

- Any additional cleaning or problems that were encountered with a specific lot

5.3 Reagents and Other Cleaning Supplies

Maintain a record of the lot number with the inclusive dates of use for all acids, solvents, and other cleaning supplies.

6.0 QUALITY CONTROL AND QUALITY ASSURANCE

As described in FQ-01-01 QA/QC Sampling, rinsate blanks will be collected at a frequency outlined in the site-specific SAP. A rinsate blank is a sample collected using organic-free water that has been run over/through sample collection equipment after the equipment has been decontaminated.

7.0 NONCONFORMANCE AND CORRECTIVE ACTION

Failure to use proper decontamination procedures can lead to cross-contamination of samples. Improperly decontaminated equipment can also lead to the spread of contamination to designated clean areas and lead to possible exposures of personnel to hazardous substances. If cross contamination is suspected or confirmed (i.e., QA/QC sample results, data validation, etc.), all site field equipment shall be decontaminated and additional QA/QC samples (Section 6.0) should be collected to document that proper decontamination procedures have been followed.

8.0 REFERENCES

Florida Department of Environmental Protection. (2004, February 1). "Cleaning/Decontamination Procedures." DEP-SOP-001/01, FC 1000, Retrieved from http://www.dep.state.fl.us/labs/assessment/SOPdoc/2004SOPS/fc1000.doc on April 7, 2006.

United States Environmental Protection Agency, Region 4. (2001, November). *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM).* U.S. Environmental Protection Agency Region 4. 980 College Station Road. Athens, Georgia 30605-2720.

ATTACHMENTS — FORMS, CHECKLISTS, AND DATA SHEETS (None)

Author	Reviewer(s)	Revisions (Technical or Editorial)
Kate Freeman	Ben Brantley	Revision 0 – April 2006 (Initial Issue)
Kate Freeman	Ben Brantley	Revision 1 – September 2019

Standard Operating Procedure
Field Documentation
SOP Number: FD-01-01

Preamble

This standard operating procedure represents EnSafe's minimum standard of practice for field documentation. State and federal requirements may vary, and EnSafe SOPs do not replace state and federal requirements which must be consulted before work begins. This SOP may be modified to meet specific regulatory, client, or project specific criteria in accordance with Section 7.0.

1.0 SCOPE AND APPLICABILITY

This SOP provides personnel with guidance for documenting sampling activities and other data collection in the field. Proper field documentation is conducted for the creation of unequivocal, accurate, and methodical records and shall be performed during all field activities. Refer to the associated sampling or field testing SOP for any requirements for the chronological or sequential documentation of data. This procedure applies to all EnSafe employees who participate in field sampling efforts.

1.1 Definitions

SAP — Sampling and Analysis Plan. A plan that outlines the sampling procedures and protocols to be followed during a field effort.

Shall or *must* — When these words are associated with a procedure or other item, the item is mandatory and expected to be performed in all cases. Deviations from the SOP containing these words shall be documented.

Should or *may* — When these words are used, the referenced item is recommended or suggested, but not mandatory.

SOP — Standard Operating Procedure. A document which gives a step-by-step description of how a specific operation, method, or procedure is performed.

1.2 Related SOPs

FQ-01-01	Quality Assurance/Quality Control Sampling
FT-01-01	General Field Testing
FT-02-01	Water Quality Parameter Testing
FD-02-02	Lithologic Logging
FS-01-01	General Sampling
FS-02-01	Soil Sampling
FS-03-01	Groundwater Sampling
FS-05-01	Diffusion Sampling
FS-06-01	Sediment Sampling
FS-07-01	Soil Gas Survey
AD-02-01	Chain of Custody

1.3 Health and Safety

All measures employed to address known or unidentified health and safety concerns during field work shall be recorded in the field logbook, safe work assessment permit (SWA), and/or job hazard analyses (JHAs).

1.4 Cautions

In addition to field data, documentation must be provided for any activity that results in (1) equipment damage, (2) degradation of environmental samples collected, (3) the possibility of invalid sample analytical results, or (4) health and safety issues. Precautionary measures shall be recorded at the critical steps for the field procedures being performed. Custody of field documentation must always be maintained and copied to the electronic project file. Field personnel must keep the documentation in a secure place when the logbook is not in personal possession.

1.5 Interferences

Improper field documentation can affect data quality, its usability, and site assessment interpretations.

1.6 Personnel Qualifications

Personnel must be knowledgeable of the procedures in this SOP. Documentation of training and familiarization with this SOP can be found in the training file for each employee. This procedure applies to all EnSafe employees who participate in environmental sampling and other data collection efforts.

2.0 APPARATUS AND MATERIALS

Field personnel shall consult the site work plan and SAP to review the field documentation requirements for a specific project or job site. Field documentation may be recorded in a field logbook, on appropriate field forms, electronically, or using other media (e.g., photographs). If appropriate for the project, EnSafe personnel shall use only bound waterproof field logbooks.

3.0 PROCEDURE

The documentation procedures will ensure that the history of a sample is clearly evident in the retained records and documentation and can be independently reconstructed. In addition, the procedures will identify storage requirements.

Criteria for All Documents

The following criteria apply to all types of documentation:

- Keep all applicable documentation available for inspection.
- Keep all original data and records as well as reduced or manipulated forms of the original data or records.
- Record enough information so that clarifications, interpretations or explanations of the data are not required from the originator of the documentation.

- Clearly indicate the nature and intent of all documentation and all record entries.
- When appropriate, link citations to SOPs and other documents by the complete name, reference or publication number, revision number and revision date for the cited document.
- Retain copies of all revisions of all cited documents as part of the documentation archives.
- Sign, initial or encode all documentation entries made to paper, electronic or other records with a link indicating the name and responsibility of the author making the data entry, clearly indicating the reason for the signature, initials or code (e.g., “sampled by”; “released by”; “prepared by”; “reviewed by”).
- Make references to procedures written in internal SOPs or methodology and procedures promulgated by external sources if possible to abbreviate record entries.
- Retain any correspondence with regulators regarding approval to use alternative procedures for any project.
- Employ straightforward archiving of records to facilitate documentation tracking and retrieval of all current and archived records for purposes of inspection, verification and historical reconstruction of all procedures and measurement data.
- Keep copies of originals of all documentation, including documentation sent to or received from external parties.
- Use permanent ink for all paper documentation. Do not erase or obliterate entry errors on paper records.
- Link final reports, data summaries or other condensed versions of data to the original sample data, including those prepared by external parties.

3.1 Manual Documentation

Manual documentation includes records completed by hand such as field logbooks, field forms, sample labels, and chain of custody forms. When manually recording information, care should be taken to write legibly so that other personnel will be able to read written documentation. The following paragraphs summarize the documentation methods and provide general guidance on data documentation.

Field Logbook

A separate field logbook is maintained for each project. If a project consists of multiple sites, a separate logbook may be designated for each site. For tasks such as water level measurements, multiple sites on one project may be recorded in one logbook.

- The project leader's name, the sample team leader's name (if appropriate), the project name and location, and the project number should be entered on the inside of the front cover of the field logbook. After the entire logbook is filled, the beginning and ending dates of activities in the logbook should be listed on the cover.

- The spine of the logbook should contain an abbreviated version of the cover information. For example, "NAS Pensacola, Site 1, 6/94 - 12/98".

- The EnSafe office address, phone, and fax number should be written inside the front cover in the event the logbook is lost.

- Each page in the logbook shall be numbered and dated. When the page numbers are handwritten, the numbers should be circled to prevent confusion with data entry.

- All entries must be legible, made with permanent ink, and contain accurate and inclusive documentation of project field activities.

- Begin each day with a new page. Each day will begin with the following information:

  — Date

  — Starting Time

  — Location

  — Weather conditions and approximate temperature

  — Name of personnel onsite. Note affiliation and designation of all personnel

  — If applicable, equipment calibration and equipment models used

  — Changes in instructions for site activities

  — Levels of personal protective clothing and equipment

  — A general title of first task undertaken (i.e., well installation at MW-12, sediment sampling at location 5 of Wetland 4)

- Corrections should be made by a drawing a single line through the entry being corrected. Initial the correction.

- Provide an approximate scale for any diagrams. If not possible, write "Not to Scale". Indicate north arrow on all maps and cross-sections. Label features on each diagram.

- At the end of each day's entries, the person making logbook entries shall draw a diagonal line, and initial it, to fill in empty space on the page and indicate the conclusion of the day's entry and departure from the site.

- Since field records are the basis of future reports related to the project, all language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate.

- Record enough information so that clarifications, interpretations, or explanations of the data are not required from the originator of the documentation.

Once completed, the field logbook becomes an accountable document and must be maintained as part of the official project file. All aspects of sample collection and handling, as well as visual observations; project-related conversations with the client, onsite contacts, or an EnSafe project manager; the analytical laboratory; media or private landowners (public), shall be documented in the field logbook.

Field Forms

In addition to the field logbook, field forms and data sheets may be used by EnSafe personnel to document field activities. The following describe some of the field forms. The forms are provided as attachments in the SOPs which are noted below:

- *Equipment Calibration Log (see SOP FT-01-01)*
  Field instruments will be calibrated daily before use according to the manufacturers' specifications. Instruments may also be calibrated during the day if field personnel consider it necessary. Instrument calibration will be recorded in the field logbook or on project-specific calibration forms.

- *Boring Log (see SOP FD-02-01)*
  The boring-log form is used to document subsurface geology and drilling/sampling activities, monitoring well construction specifications, and general information pertinent to a particular soil sampling or monitoring well location. Specifically, the form documents the drilling/sampling method, lithologic description, boring/well depth, sample intervals, groundwater depth, and other drilling details.

- *Groundwater Sampling Form (see SOP FS-03-01)*
  The well development/groundwater sampling form is used to document site conditions and activities during monitoring well development and groundwater sampling. The form shall document site information and data including sampling personnel, the sampling equipment used, well construction information and/or well volume, groundwater quality measurements collected, volume of groundwater pumped/purged from the well.

- *Chain-of-Custody Form (see SOP AD-02-01)*
  The chain-of-custody (COC) form must be completed for all samples collected and analyzed in the course of a project. COC documentation will commence upon sample collection and will include information for each sample: unique sample ID, sample collection date (day, month, and year) and time, type and number of sample containers, preservation data, and sample analysis. The form also lists client information, the EnSafe project manager, the field sampler(s), and the job number/purchase order number/release number (information specific to the contract with the analytical laboratory). Additional information includes the date/time that custody is released by EnSafe, the name/signature of the employee releasing custody of the samples and the name/signature of the laboratory employee accepting custody. The signature of any individual on the COC form is that person's assertion that they personally handled or processed the samples identified on the record. The shipping method is also listed on the form. Special instructions for the contracted laboratory can also be listed on the COC form. The individual(s) collecting the samples will complete a COC form; the form will accompany each sample shipment to document the transfer of

custody from the time and point of collection until delivery to the laboratory for analysis. Copies of COC forms are kept by the site manager to be given to the project manager at the completion of the field effort.

- *Sample Label (See SOP AD-02-01)*
  The sample label is used to identify the collected sample. The sample label shall be filled out with permanent ink and contain the site/project name, the unique sample ID, the type of analyses to be performed, the date/time of collection, the sample preservative, and the names or initials of the field personnel who collected the sample.

  If sample IDs are known in advance of sample collection, sample labels may be prepared in advance, with the date and time of collection and the names of field personnel added at the time of collection. Label information can be pre-printed electronically or filled out legibly by hand. Field personnel shall correctly fill out sample labels and attach them to the appropriate sample containers at the time of collection. Care will be taken to ensure that water or soil on the outside of the container does not interfere with the proper adhesion of the label or legibility of the sample label information.

- *Chain-of-Custody Seal (See SOP AD-02-01)*
  The COC seal is used to ensure that the collected samples are not tampered with or disturbed during handling and shipment. All sample shipping coolers should be sealed with COC seals prior to shipment to the analytical laboratory. Some projects may require that COC seals be placed on individual sample containers.

Documentation of Equipment Maintenance

Log all maintenance and repair performed for each instrument unit, including routine cleaning procedures, corrective actions performed during calibrations or verifications, and solution or parts replacement for instrument probes. The following information shall be recorded or retained regarding equipment maintenance:

- The calendar date for the procedures performed.
- Names of personnel performing the maintenance or repair tasks.
- Malfunctions necessitating repair or service.
- Identity of specific instrumentation in the documentation with a unique description or code for each instrument unit employed. This may include a manufacturer name, model number, serial number, inventory number, etc.
- Retain vendor service records for all affected instruments.

For rental equipment, document or retain the following information:

- Rental date(s)
- Equipment type and model or inventory number or other description

- Retain the manufacturer's operating and maintenance instructions.

Instrument or Method Calibration

Document the acceptable calibration data for the instruments or other measuring systems used during field sample collection and/or field tests and analyses in the field logbook or on an acceptable field form.

The following information shall be recorded about standards and reagents used for calibrations, verifications and sample measurements.

- Note the date of receipt, the expiration date and the date of first use (if known) for all standards and reagents.
- Document acceptable verification of any standard used after its expiration date.
- Record the concentration or other value for the standard in the appropriate measurement units.
- Note vendor catalog number and description for preformulated solutions as well as for neat liquids and powdered standards.
- Retain vendor assay specifications for standards as part of the calibration record.
- Record the grade of standard or reagent used.

Field Instrument Calibration Documentation:

- Document acceptable calibration and calibration verification for each instrument unit and field test or analysis, linking this record with affected sample measurements.
- Retain vendor certifications of all factory-calibrated instrumentation.
- Designate the identity of specific instrumentation in the documentation with a unique description or code for each instrument unit used.
- Record manufacturer name, model number and identifying number such as a serial number for each instrument unit.
- Record the time and date of all initial calibrations and all calibration verifications.
- Record the instrument reading (value in appropriate measurement units) of all calibration verifications.
- Record the name of the analyst(s) performing the calibration or verification.

- Document the specific standards used to calibrate or verify the instrument or field test with the following information:

  — Type of standard or standard name (e.g., pH buffer)
  — Value of standard, including correct units (e.g., pH = 7.0 SU)

- Retain manufacturers' instrument specifications.

- Document whether successful initial calibration occurred.

- Document whether each calibration verification passed or failed.

- Document, according to records requirements of any corrective actions taken to modify instrument performance.

- Document date and time of any corrective actions.

- Note any incidence of discontinuation of use of the instrument due to calibration failure.

- Describe or cite the specific calibration or verification procedure performed (FDEP SOP or internal SOP).

Sample Identification

- Label or tag each sample container with a unique field identification code that adequately distinguishes each sample according to the following criteria. The code must adequately link the sample container with all of the information about the sample contained in the permanent field record.
- Link the unique field identification code to the sample source or sampling point identification, the date of sample collection, the time of sample collection (for maximum holding times equal to or less than 48 hours), the analytes of interest and the preservation technique.

- Quality control samples, such as duplicate samples, other replicate samples and split samples, collected from the same sample source or sampling point on the same date and at the same time, must be identified and labeled or tagged with different field identification codes if the identical sample collection procedures are used for the QC samples and the QC samples are collected for the same analyte or group of analytes.

- Samples collected from the same sample source or sampling point on the same date and at the same time must be identified and labeled differently if more than one sample collection technique is used to collect samples for the same analyte or group of analytes. For example, if both a bailer and a pump are used to collect samples for metals analysis, the bailer sample must be labeled to distinguish it from the pump sample.

- The unique field identification code and any other information included on the container label or tag must allow the analyzing laboratory to independently determine the sample

collection date, the sample collection time (for maximum holding times less than 48 hours), the sample preservation and the analytical tests to be performed on each container or group of containers.

- Attach the label or tag so that it does not contact any portion of the sample that is removed or poured from the container.

- Record the unique field identification code on all other documentation associated with the specific sample container or group of containers.

Sample Documentation

During collection of each environmental sample, the following information and data, at a minimum, must be recorded in the field logbook or on the appropriate field forms:

- Field sampling equipment used

- Field analytical equipment and other equipment used for physical measurements

- Calculations, field analytical results, calibration data for field sampling, physical measurement (e.g., total well depth, static water level depth, length of water column, presence of accumulated silt or free-phase contaminants)

- Sampling location identification

- Date and time using 24 hour clock of sample collection

- Description of the sample location, if necessary for accurate identification
- Maps/sketches of sample locations, if necessary for accurate identification

- Sample description (as appropriate), preservation techniques, laboratory analytical methods for which the sample is being collected, and types of containers used to hold the sample

- The names of field personnel collecting the sample, and those present during the sampling

- Type of sample (e.g., grab, composite)

- Weather conditions or anthropogenic influences (e.g., car exhaust fumes) that may be present during collection of a sample, and which may potentially influence laboratory analysis of that sample.

Sample Chain-of-Custody Form

Transmit the following information to the analytical laboratory or other receiving party. Link transmittal records with a given project and retain all transmittal records.

- Site name and address

- Client code is acceptable if samples are considered sensitive information and if the field records clearly trace the code to a specified site and address.
- Date and time of sample collection
- Name of sampler responsible for sample transmittal
- Unique field identification codes for each sample container
- Total number of samples
- Required analyses
- Preservation protocol
- Comments about sample or sample conditions
- Identification of common carrier (if used)

Sample Transport

- If shipping transmittal forms in the transport containers with the samples, place the forms in a waterproof enclosure and seal.
- All shipping coolers should be sealed with COC seals before shipment to the laboratory. Some projects may require that COC seals be placed on individual sample containers.
- Seal shipping containers with strapping tape.
- Keep all shipping bills from common carriers with archived transmittal records.
- If the same party collects, packs and delivers the samples to the laboratory, custody seals are not needed on the shipping container.

Decontamination Documentation

Document all cleaning procedures by stepwise description or cite the Field Decontamination SOP, FC-01-01. Record the date of cleaning. If items are cleaned in the field during sampling activities for a site, document the date and time when the affected equipment was cleaned. Link this information with the site and the cleaning location at the site.

Retain or make accessible any certificates of cleanliness issued by vendors supplying cleaned equipment or sample containers. Retain from the vendor or document for internal cleaning the following information for sample containers, as applicable:

- Packing slip and cleanliness certificates from vendor
- Container types and intended uses

- Lot numbers or other designations for groups of containers cleaned together using the same reagents and procedures
- Dates of cleaning
- Cleaning procedures or reference to internal cleaning SOPs
- Cleaning personnel names
- Results of quality control analyses associated with container lots
- Comments about problems or other information associated with container lots

Documentation for Reagents and other Chemicals
Keep a record of the lot numbers and inclusive dates of use for all reagents, detergents, solvents and other chemicals used for cleaning and sample preservation.

3.2 Electronic Documentation

3.2.1 Retention of Automatic Data Recording Products

For data not directly read from the instrument display and manually recorded, retain all products or outputs from automatic data recording devices, such as strip chart recorders, integrators, data loggers, field measurement devices, computers, etc. Store records in electronic, magnetic, optical or paper form, as necessary.

Retain all original, raw output data. Ensure archiving of these data prior to subsequent reduction or other manipulation of the data. Identify output records as to purpose, analysis date and time, field sample identification number, etc. Maintain unequivocal linkage with the associated sample, other data source or measured medium and specific instrument used to make the measurement.

Electronic Data Security
Control levels of access to electronic data systems as required to maintain system security and to prevent unauthorized editing of data. Do not alter raw instrumentation data or original manual data records in any fashion without retention of the original raw data. Maintain secure computer networks and appropriate virus protection as warranted for each system design.

Electronic Data Storage and Documentation
Store all electronic, magnetic and optical media for easy retrieval of records. Ensure that all records can be printed to paper if needed for audit or verification purposes. If it is anticipated that the documentation archive will become unreadable due to obsolescence of a particular storage technology, retain a paper archive of the data or transfer to other suitable media. For easy retrieval of records, link all stored data to the associated sample data or other data source. Back up all data at a copy rate commensurate with the level of vulnerability of the data. Consider replicating all original data as soon as possible after origination.

Software Verification
Ensure that any software used to perform automatic calculations conforms to required formulas or protocols. Document all software problems and their resolution in detail, where these problems have irretrievably affected data records or linkage. Record the calendar date, time, responsible personnel and relevant technical details of all affected data and software files. Note all software changes, updates, installations, etc. per the above concerns. File and link all associated service records supplied by vendors or other service personnel.

Protection of Equipment and Storage Media
Place stationary computers, instrumentation and peripheral devices in locations of controlled temperature and humidity and away from areas where the potential for fluid leaks, fire, falling objects or other hazards may exist. In the field, protect portable equipment from weather, excess heat or freezing, storage in closed vehicles, spillage from reagents and samples, etc.

Protect storage media from deteriorating conditions such as temperature, humidity, magnetic fields or other environmental hazards as above.

3.3 Documentation Using Other Media
Store media such as photographs, photographic negatives, microfilm, videotape, etc. under conditions generally prescribed for these media by manufacturers and conducive to long-term storage and protection from deterioration.

For each photograph taken a site, the following information shall be recorded in the field logbook:

- Time, date (if not automatically date stamped), location, direction, and if appropriate, weather conditions

- Description of subject and
- Sequential number of photograph and film roll number (if applicable)

- Name of photographer

3.4 Sample Analysis (Not Applicable)

4.0 DATA ACQUISITION, CALCULATIONS AND DATA REDUCTION
Any calculations or measurements performed in the field shall be appropriately documented in the Field Logbook or on field forms.

5.0 DATA/RECORDS MANAGEMENT
At the completion of a field effort, all logbooks and field forms shall be given to the project manager and will be maintained as a part of the project file. A copy of the logbooks and field forms may be maintained by the field person in case the documents become lost or the project manager has questions about the project.

6.0 QUALITY CONTROL AND QUALITY ASSURANCE

At the conclusion of field work, all field notes or project documentation should, at a minimum, be reviewed for accuracy, SOP deviations, and completeness. If practical, field documentation should be reviewed on a daily basis during extended field activities; such frequent reviews may help identify any potential problems and provide opportunities to implement corrective action measures during the field event.

7.0 NONCONFORMANCE AND CORRECTIVE ACTION

It is imperative that field personnel document field activities in accordance with the instructions in this SOP and any site-specific SAP or work plan requirements. Improper field documentation can lead to questionable or invalid analytical sample results, which may necessitate that sampling efforts be repeated.

8.0 REFERENCES

Florida Department of Environmental Protection. (2004, February 1). "Documentation Procedures." DEP-SOP-001/01, FD 1000, Retrieved from http://www.dep.state.fl.us/labs/assessment/SOPdoc/2004SOPS/fd1000.doc. on April 7, 2006.

United States Environmental Protection Agency, Region 4. (2001, November). *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM).* 980 College Station Road. Athens, Georgia 30605-2720.

Attachments — Forms, Checklists, and Data Sheets

None

Author	Reviewer(s)	Revisions (Technical or Editorial)
Phil Hardy	Allison Harris	Revision 0 — April 2006 (Initial Issue)
Phil Hardy	Ben Brantley	Revision 1 – September 2019

Standard Operating Procedure
Packing and Shipping Non-Hazardous Environmental Samples

These standards will ensure continuity within the organization.

Preamble

This standard operating procedure (SOP) is designed to provide the user standards on packing and shipping environmental samples after they have been collected so they arrive at their destination in a condition that meets the quality objectives required by the site's sampling and analysis plan (SAP). This SOP assumes the environmental samples have not been characterized as hazardous. If they are classified as hazardous then additional procedures will have to be followed that are not discussed in this SOP.

Before using this SOP, the user is required to determine whether it meets the state-specific and federal minimum standards. If a difference exists between state and federal SOPs than those contained herein, the state and federal SOPs take precedence. If this SOP is modified per agreement between management-level parties associated with the activity, the agreed changes will become part of the site-specific SOP and the modifications will be appended to this SOP for the record.

1.0 SCOPE AND APPLICABILITY

This SOP sets forth the methods for use by personnel engaged in handling, packing, and shipping non-hazardous environmental samples. As guidance for specific activities, this procedure does not remove the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved by the parties responsible for such activities.

1.1 Definitions

Shall or *must* — When these words are associated with a procedure or other item, the item is mandatory and expected to be performed in all cases. Deviations from the SOP containing these words shall be documented.

Should or *may* — When these words are used, the referenced item is recommended or suggested, but not mandatory.

1.2 Related SOPs (None)

1.3 Health and Safety

When in the field, at a minimum, the following personal protective equipment must be worn:

- Gloves, such as blue nitrile and latex, as defined in the site-specific project health and safety plan, when handling sample containers to avoid contacting any materials that may have spilled out of the sample containers
- Safety glasses
- Steel toed boots
- Appropriate clothing to prevent spillage from contacting exposed skin

Additional caution should be implemented, such as:

- To avoid lifting injuries associated with heavy coolers, use the large muscles of the legs, not the back. Use hand carts, if possible or perform the lifting as part of a team of two members.
- When using cutting tools, cut away from yourself. The use of appropriate, intrinsically-safe cutting tools is recommended.
- Handle glass containers with care. Discard any broken glass in a waste container that cannot be punctured.
- Acid used as preservatives should be cleaned up immediately if spilled. If a spill occurs on exposed skin or clothing use the proper procedure to reduce exposure time.
- Make sure all sample lids and caps are secured before packing into shipping coolers; this will help eliminate potential exposure of laboratory personnel receiving the environmental samples.

1.4 Cautions
None other than Health and Safety in Section 1.3.

1.5 Interferences (None)

1.6 Personnel Qualifications
This procedure will be implemented by professionals who, through prior training and/or experience, are knowledgeable about the procedures for identification of environmental samples.

2.0 PROCEDURES
Environmental samples should be packaged prior to shipment using the following procedures:

1. Inspect the cooler for integrity and structural damage and be sure it is clean. Also check the handles to be sure they are secure. If the shipping cooler is damaged, do not use. Damaged cooler should be made unusable and discarded.
2. For a 20-gallon cooler (14”x14”x24”) put a clean, 39-gallon + trash bag in the cooler and open it up so that you have complete access to the inside. Smaller cooler will require smaller size plastic trash bag.
3. Inside the trash bag build a “nest” with bubble wrap or a similar sheet packing material on the bottom and sides.
4. Take double-bagged self-sealing bags filled with wet ice and put/layer bags on the bottom of the cooler in the “nest”. 1- or 2-gallon bags are ideal for this.
5. Next, if applicable, put a temperature blank in the bottom of the nest.

6. Glass sample bottles should be wrapped in bubble wrap — preferably sealable bubble wrap sample bags, if available. Place bottles in separate and appropriately-sized polyethylene bags and seal the bags. **MAKE SURE SAMPLES HAVE BEEN APPROPRIATELY LABELED AND RECORDED ON THE CHAIN OF CUSTODY BEFORE PLACING IN SAMPLE BAGS.**

7. Place the wrapped sample containers to be shipped to the inside of the nest. Make sure the containers are place in the vertical or upright orientation. Do not lay them on their sides.

8. As containers are added to the cooler, continue to strategically place ice filled double-bagged self-sealing bags between the sample packages. There is no hard and fast rule on how much ice to use (frequently 2-3 bags at least), but if there is any doubt use more ice than less and use extra cooler(s) with additional temperature blanks and trip blanks, if necessary, to spread the container load. If possible, put a layer of double bagged ice over the samples before sealing the protective plastic trash bag.

9. Pull the trash bag assemblage of "nested" containers-ice-bubble wrap tightly together and then twist the top into and tie it off. If there are any void spaces remaining in the cooler, insert some type of packing material into them. The samples should not be allowed shift in transit; thus, reducing the potential for breakage.

10. Put the complete-signed chain-of-custody into a self-sealing bag, affix/tape the bag to the underside of the cooler lid. **DOUBLE CHECK THE NUMBER OF SAMPLES THAT ARE BEING SHIPPED TO WHAT IS ON THE CHAIN OF CUSTODY BEFORE SEALING THE COOLER TO ENSURE THEY MATCH.**

11. Pre-tape the lid by holding the cooler lid tightly shut, then run some clear packing tape around it, just enough to hold it closed. Then if possible run lines of tape around both sides of the cooler and around the top seam of the lid-cooler body. If the cooler has a plug, make sure that is taped shut.

12. Once pre-taped add signed custody seals (see example in Attachment 1), when applicable, across the seam of the lid and body of the cooler in a staggered fashion. One seal on the hinge side of the cooler at one end, and one seal on the opening side of the cooler on the other end.

13. Add a sticker or tape a small sign to the cooler with the shipping address and phone# of the laboratory. Then affix any other stickers (perishable, wet ice, etc.).

14. Final taping should be done with loops of clear packing tape around the custody seals on each end of the cooler and across the lid-body seam. Use at least 8-10 loops of tape, and more if needed. If there are multiple coolers to multiple destinations, colored tapes on the coolers in each shipment can help to reduce confusion.

15. The cooler is ready to be shipped.

16. Follow all appropriate Department of Transportation regulations for shipment of air, soil, water, and other samples. For non-hazardous environmental samples, the samples may be shipped as non-hazardous. When a cooler is ready for shipment to the laboratory, prepare a standard bill of lading for shipment. Keep a copy of the bill of lading and notify the laboratory the samples are being shipped and the shipping tracking number. Write the tracking number in the field log book with date and time.

    Add additional information on the cooler such as:

    - Fragile
    - Temperature-controlled sticker
    - This-End-Up (or directional arrows pointing up), and/or
    - The number of the cooler if multiple coolers are being shipped under one bill of lading (1 of 3, 2 of 3, and 3 of 3).

17. Retain bill of lading from commercial transportation carrier that contains the tracking number.

18. Although not required, it is highly recommended that the sampler forward the tracking number to the laboratory via email.

3.0 DATA/RECORDS MANAGEMENT

Maintain all copies of chain of custodies and bills of lading with the project file.

4.0 QUALITY CONTROL AND QUALITY ASSURANCE

The COC form should be reviewed independently from the generator.

5.0 NONCONFORMANCE AND CORRECTIVE ACTION

Any deviations from the standard protocol or any problems that occur during procedure implementation must be documented in the logbook or forms and corrective action should be applied, if warranted.

6.0 REFERENCES (None)

7.0 FORMS AND DATA SHEETS

Attachment 1 — Example Chain-of-Custody Seal

Author	Reviewer	Revisions (Technical or Editorial)
Ben Brantley	Tina Cantwell	Revision 0 – May 2006 (Initial Issue)
Tammy Williams	Tina Cantwell	Revision 1 – August (Editorial/Re-format)
Tina Cantwell	Tom Deck	Revision 2 – July 2019 (Editorial/Re-format)

Attachment 1
Example Chain-of-Custody Seal

EXAMPLE CHAIN-OF-CUSTODY SEAL

ENSAFE	SAMPLE NO.	DATE	SEAL BROKEN BY
	SIGNATURE		DATE
	PRINT NAME		

Standard Operating Procedure
Quality Assurance/Quality Control Sampling

SOP Number: FQ-01-01

Preamble

This standard operating procedure (SOP) represents EnSafe's minimum standard of practice for quality assurance and quality control sampling. State and federal requirements may vary, and EnSafe SOPs do not replace state and federal requirements, which must be consulted before work begins. This SOP may be modified to meet specific regulatory, client, or project-specific criteria in accordance with Section 7.0.

1.0 SCOPE AND APPLICABILITY

The purpose of this Standard Operating Procedure (SOP) is to describe types of Quality Assurance/Quality Control (QA/QC) samples that are collected in the field or prepared for or by the laboratory for soil and water matrices. The goal of including QA/QC samples with any sampling or analytical event is to be able to identify, measure, and control the sources of error that may be introduced from the time of sample-container preparation through sample analysis. Quality control samples are collected during field studies for various purposes, which include defining background conditions (background sample) and evaluating field/laboratory variability (spikes and blanks, trip blanks, duplicate, split samples). Sample types are discussed under the Procedure section of this SOP.

Individual states and U.S. Environmental Protection Agency Regions provide guidance on the types and frequencies of QA/QC samples that should be collected to support field sampling collection. Therefore, state and or regional guidance should be consulted prior to developing QA/QC sampling strategies. Additionally, project-specific goals defined in approved Work Plans, Field Sampling Plans, and/or Quality Assurance Project Plans should always take precedence over the guidance provided herein.

1.1 Definitions

QA/QC — Quality Assurance/Quality Control. The term QA/QC is often used to refer to the actions performed for ensuring the quality of a product, service, or process.

SAP — Sampling and Analysis Plan. A plan that outlines the sampling procedures and protocols to be followed during a field effort.

SOP — Standard Operating Procedure. A document that gives a step-by-step description of how a specific operation, method, or procedure is performed.

VOC — Volatile Organic Compound. Any organic compound that evaporates readily to the atmosphere.

Shall or *must* — When these words are associated with a procedure or other item, the item is mandatory and performance is expected in all cases. Deviations from the SOP containing these words shall be documented.

Should or *may* — When these words are used, the referenced item is recommended or suggested, but not mandatory.

1.2 Related SOPs

The following sampling SOPs shall be used in conjunction with this SOP:

FD-01-01	Field Documentation
FS-01-00	General Sampling
FS-02-00	Soil Sampling
FS-03-00	Groundwater Sampling
FS-04-00	Pore Water Sampling
FS-05-01	Diffusion Sampling
FS-06-00	Sediment Sampling
FS-07-00	Soil Gas Survey
FS-08-00	Surface Water Sampling
FS-09-00	Potable Water Supply Sampling
FS-10-00	Contaminated Surface Sampling
FS-11-00	Waste and IDW Sampling
FS-12-00	PFAS Sampling
FS-13-01	Asbestos Sampling
FS-14-00	Wastewater Sampling
FS-15-00	Tissue Sampling
FS-17-00	Stormwater Sampling
FS-10-01	Lead Based Paint Sampling

1.3 Health and Safety

Health and safety considerations will vary according to the individual sites. Personnel shall review available site-specific Health and Safety Plans and/or safe work and assessment permit (SWAP) to become familiar with the job hazards and safety requirements for the site at which they will be working.

1.4 Cautions

QA/QC samples are collected and analyzed in addition to environmental samples to assist in identifying the origin of both field and laboratory contamination. In order to provide useful information, QA/QC samples must be taken and analyzed in the same manner as the environmental samples. Failure to do so may result in invalid QA/QC interpretations.

1.5 Interferences

Site conditions and weather can impact QA/QC. When unfavorable conditions are present, they should be noted in a field logbook and every reasonable effort be made to preserve QA/QC sample integrity.

1.6 Personnel Qualifications

Personnel are required to be knowledgeable of the procedures in this SOP. Documentation of training and familiarization with this SOP can be found in the training file for each employee.

2.0 APPARATUS AND MATERIALS

The site-specific equipment/apparatus required to collect QA/QC samples is the same as the equipment/apparatus required to collect the environmental samples. Refer to the relevant SOPs for sampling techniques to obtain lists of the equipment/apparatus required for sampling.

3.0 PROCEDURES

QA/QC samples are discussed below. Each type of sample is defined and a preparation procedure is outlined. In addition, the minimum frequency of collection of these QA/QC samples is discussed. When collected, analyze all quality control samples for the same parameters as the associated samples, depending on the project-specific objectives. Samples collected for general information, monitored natural attenuation, or screening may not require the collection of QA/QC samples. Please refer to individual project plans for developing QA/QC sampling strategies.

3.1 Instrument or Method Calibration

(Not Applicable)

3.2 Sample Collection

The sample collection procedures required to collect QA/QC samples are the same as those used to collect the environmental samples. Refer to the relevant sampling SOPs for applicable procedures. The following sections describe field QA blanks, duplicates, and matrix spike/matrix spike duplicate sample collection.

3.2.1 Quality Control Blanks

Quality control blanks applicable for QA/QC sampling are described below.

Blanks are required for:

- Volatile Organics
- Extractable Organics
- Inorganic Nonmetallic
- Petroleum Hydrocarbons and Oil & Grease
- Radionuclides
- Metals
- Volatile Inorganics
- Aggregate Organics except Biochemical Oxygen Demand

Blanks are not required for:

- Toxicity
- Radon
- Algal Growth Potential
- Biological Community
- Physical and Aggregate Properties
- Biochemical Oxygen Demand
- Field parameters such as pH, specific conductance, residual chlorine, temperature, dissolved oxygen, and oxidation reduction potential

General Quality Control Blank Requirements

- Preserve, transport, document, and handle all quality control samples as if they were actual field samples. Once collected, they must remain with the sample set until the laboratory has received them.

- Prepare equipment rinsate blanks by rinsing the sampling equipment set with the appropriate type of analyte-free water and collecting the rinsate in appropriate sample containers.

- Except for trip blanks, prepare all quality control samples **on-site in the field**.
- Do not prepare equipment blanks in advance.
- Do not prepare equipment blanks after leaving the sampling site.

Trip Blank — a sample that is prepared prior to the sampling event and is stored with the investigative samples throughout the sampling event. Trip blanks are packaged for shipment with the other samples and submitted for analysis.

- Use: Monitors sample container cleaning and the suitability of sample preservatives and analyte-free water. Monitors sample transport and storage conditions.
- Unless superseded by project, state, and/or regional requirements, these blanks are applicable if samples are to be analyzed for volatile constituents.
- The organization or laboratory providing the VOC vials must provide the trip blanks by filling one or more VOC vials with analyte-free water.
- Place a set of trip blanks in each transport container used to ship/store empty VOC vials. They must remain with the VOC vials during the sampling episode and must be transported to the analyzing laboratory in the same shipping or transport container(s) as the VOC samples.
- Trip blanks must be opened **only** by the laboratory after the blank and associated samples have been received for analysis.

Equipment Rinsate Blank — a sample collected using organic-free water that has been run over/through sample collection equipment. These samples are used to determine if contaminants have been introduced via contact of the sample medium with sampling equipment.

- Use: Monitors onsite sampling environment, sampling equipment decontamination, sample container cleaning, the suitability of sample preservatives and analyte-free water, and sample transport and storage conditions.
- Collect these blanks using sampling equipment that has been cleaned in the field (i.e., between sampling locations).

Field Blank — a sample that is prepared in the field to evaluate the potential for contamination of a sample by site contaminants from a source not associated with the sample collected.

- Use: Monitors onsite sampling environment, sample container cleaning, the suitability of sample preservatives and analyte-free water, and sample transport and storage conditions.

- Prepare field blanks by pouring analyte-free water into sample containers for each parameter set to be collected.

- Field blanks are not required if equipment blanks are collected but may be collected to assess source water independent of cleaning activities.

- Collect field blanks if no equipment except the sample container is used to collect the samples or if the sampling equipment is certified clean by the vendor or the laboratory providing the equipment.

Material Blank — a sample that monitors sampling materials (e.g., material used to collect wipe samples, etc.), construction materials (e.g., well construction materials), or reagents (e.g., organic/analyte free water generated in the field, water from local water supplies used to mix well grout, etc.).

- Use: Collected to measure any positive bias from sample handling variability.

- Prepare material blanks using the same procedures used to collect investigative samples.

Material blanks are only required as dictated by project-specific goals. Commonly collected material blanks are listed below:

Wipe Sample Blank: a sample of the material used for collecting wipe samples.

Grout Blank: a sample of the material used to make seals around the annular space in monitoring wells.

Filter Pack Blank: a sample of the material used to create an interface around the screened interval of a monitoring well.

Construction Water Blank: a sample of the water used to mix or hydrate construction materials such as monitoring well grout.

Organic/Analyte Free Water Blank: a sample collected from a field organic/analyte-free water generating system.

Temperature Blank — a clean water sample for the laboratory to measure cooler temperature upon receipt.

- Use: Monitors the temperature of the samples requiring preservation by cooling to 4°C during shipment.

- If not provided by the laboratory, place a non-preserved small container of water in each sample cooler preserved with ice.

- Temperature blanks may not be required by laboratories that use laser thermometers. Please consult with each individual laboratory to ascertain the need to ship temperature blanks.

3.2.2 Replicate Samples

Duplicate Sample — a field sample obtained from one location that is separated into two samples. Duplicate samples are divided into separate containers; one duplicate sample is considered separate from the other duplicate sample throughout the remaining sample handling and analytical processes. These samples are used to assess total error (precision) associated with sample heterogeneity, sample methodology, and analytical procedures.

- Use: Designed to measure the variability in the sampling process.

- Soil duplicate samples are homogenized in a pre-cleaned intermediate vessel (e.g., mixing bowl) before being split. Samples submitted for VOC analysis are not homogenized.

- Water duplicate samples are collected by **repeating** (simultaneously or in rapid succession) the entire sample acquisition technique that was used to obtain the first sample.

- Collect, preserve, transport, and document duplicates in the same manner as the samples.

- Different sample identifications must be used for duplicates than for original samples.

- Depending on project-specific goals, field duplicates should be analyzed for the same parameters as the associated samples.

- When possible, collect duplicate samples from sampling locations where contamination is present.

Split Sample — Split samples are field samples obtained from one location and divided into separate containers. They are treated the same as field duplicate samples except that they are sent to separate laboratories for analysis to measure the variability **between** laboratories. Samples may be split with regulatory agencies where they may serve as an oversight function. Collect split samples using the following procedures:

- Use: Designed to measure the variability between two laboratories.

- Soil split samples are homogenized in a pre-cleaned intermediate vessel (e.g., mixing bowl) prior to being split. Samples submitted for VOC analysis are not homogenized.

Water samples should be filled from consecutive sample volumes from the same sampling device. If the sampling device does not hold enough volume to fill the containers, use the following procedure:

- Fill the first container with half of the sample and pour the remaining sample into the second container.

- Obtain an additional sample, pour the first half into the second container, and pour the remaining portion into the first container.

- Continue with steps described in steps a and b until both containers are filled.

Matrix Spike and Matrix Spike Duplicate samples (MS/MSDs) — are environmental samples that are spiked in the laboratory with a known concentration of a target analyte(s) to verify percent recoveries. Matrix spike and matrix spike duplicate samples are primarily used to check sample matrix interferences. They can also be used to monitor laboratory performance. MS/MSDs are required to be performed by laboratories per the analytical methods at a frequency of 1 per 20 samples analyzed; however, they may or may not need to be performed on site samples, depending on the project specific goals. When collected, the following procedures should be used.

- Use: Designed to measure the precision and accuracy in the analytical process.

- When collected, water MS/MSDs are to be collected in **triplicate** volume, using the same sample procedures as field duplicates.

- Soil MS/MSDs are also collected using the same procedures for duplicate samples; however, triplicate volume is not required.

- MS/MSDs must be identified using the same identification as the parent sample and must be identified on the chain-of-custody to inform the laboratory that the sample is intended to be used for spiking.

- Samples chosen for spiking should be representative of the matrix indicative of site conditions. When possible, spiked samples should be obtained from a non-contaminated area.

- Collect, preserve, transport, and document duplicates in the same manner as the samples.

- Depending on project-specific goals, MS/MSDs should be analyzed for the same parameters as the associated samples.

Background Samples — are collected from area(s), either onsite or offsite where there is little or no chance of contamination. Background samples are collected in an attempt to determine the natural composition of the media (especially important in areas with high concentrations of naturally occurring metals) and are considered "clean" samples. They provide a basis for comparison of contaminant concentration levels with samples collected onsite. Background samples may or may not need to be collected, depending on the project-specific goals. When collected, the following procedures should be used.

- Use: Designed to assess naturally occurring concentrations in a given area.

- When collected, background samples follow the same procedures used to collect site investigation samples.

- Depending on project-specific goals, at least one background sample of each sampled media should be collected. More are warranted when the following conditions exist: site-specific factors such as natural variability of local media; multiple onsite contaminant source areas; or offsite facilities that may potentially contribute to contamination.

- Collect, preserve, transport, and document background samples in the same manner as the investigation samples.

- Depending on project-specific goals, background samples should be analyzed for the same parameters as the associated samples.

3.3 Sample Handling and Preservation

Sample containers must be free from contamination by the analytes of interest or any interfering constituents and must be compatible with the sample type. The amount of sample to be collected, the proper sample container, chemical preservation, and storage requirements are discussed in the sample storage, preservation, and handling SOP. QA/QC samples for soil and water matrices are discussed below. Each type of sample is defined and a preparation procedure is outlined. In addition, the minimum frequency of collection of these QA/QC samples is discussed.

3.4 Sample Analysis

Samples collected for QA/QC sampling may be analyzed in the field or by a laboratory. Refer to the relevant SOPs for applicable field procedures. Samples analyzed by the laboratory will adhere to applicable analytical methods and their internal SOPs.

4.0 DATA ACQUISITION, CALCULATIONS, AND DATA REDUCTION (None)

5.0 DATA/RECORDS MANAGEMENT

1. Document all field quality control measures in the permanent field records or forms.

2. At a minimum, the type, time, and date that the quality control sample was collected will be recorded.

3. If blanks are collected/prepared, maintain records of the following:
   - Type of analyte-free water used
   - Source of analyte-free water (include lot number if commercially purchased)
   - A list of the sampling equipment used to prepare the blank.

4. For duplicates, record the technique that was used to collect the sample.

5. For split samples, identify the method used to collect the samples and the source(s) of the sample containers and preservatives.

6. Completed logbooks and forms will be submitted to and maintained by the project manager (or designee) after completion of the activity.

7. All QA/QC deviations from project-specific plans shall be documented in the field logbook.

6.0 QUALITY CONTROL AND QUALITY ASSURANCE

Individual states and U.S. Environmental Protection Agency Regions provide guidance on the types and frequencies of QA/QC samples that should be collected to support field sampling collection. Attachment A provides guidance for the typical QA/QC sampling frequencies and may or may not be relevant to each site. **It is incumbent upon the project manager and/or sampling team to become familiar with state and regional guidance before developing QA/QC sampling plans.**

7.0 NONCONFORMANCE AND CORRECTIVE ACTION

Any deviations from the standard protocol or any problems that occur during procedure implementation must be documented in the logbook or forms and corrective action should be applied, if warranted.

8.0 REFERENCES

Florida Department of Environmental Protection. (2004, February 1). "Field Quality Control Requirements." DEP-SOP-001/01, FQ 1000, Retrieved from http://www.dep.state.fl.us/labs/assessment/SOPdoc/2004SOPS/fq1000.doc on April 7, 2006.

United States Environmental Protection Agency, Region 4. (2001, November). *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM).* 980 College Station Road. Athens, Georgia 30605-2720.

ATTACHMENTS — FORMS, CHECKLISTS, AND DATA SHEETS

Attachment 1 provides guidance for QC sample frequencies.

Author	Reviewer(s)	Revisions (Technical or Editorial)
Tina Cantwell	Allison Harris	Revision 0 – April 2006 (Initial Issue)
Tina Cantwell	Ben Brantley	Revision 1 - September 2019

Attachment 1 QC Sample Frequency			
Quality Control Sample	**Guidance for Collection Frequency**	**Volume Required**	**Comments on Collection Frequency**
Trip Blanks	One per shipping cooler containing volatile organic constituents.	Standard volume or as required by laboratory procedures	Trip blanks may also be sent for other constituents (particularly gasoline-range petroleum organics) depending on state or regional guidelines. Frequency depends on the governing regulatory agency. Some states/regions require fewer trip blanks [e.g., one every other day or one per shipment (and not cooler).]
Equipment Rinsate Blanks	Soil — Blanks should be collected for each type of sampling apparatus at a minimum of one per week. Water — One per week for each sampling apparatus. It is suggested that a blank be collected for each new batch of tubing used in the monitoring wells. Not required if field cleaning is not performed or when dedicated groundwater tubing is used.	Standard volume	Frequency depends on the governing regulatory agency; some agencies require frequencies of one blank per day or one every 10 samples.
Field blanks	If collected, collect at the beginning of each sampling event and when source water is changed. Not required if equipment blanks are collected but may be collected to assess source water independent of cleaning activities; collect at the beginning of each sampling event.	Standard volume	Frequency depends on the governing regulatory agency.
Material Blanks	Collect only if required for project.	Standard volume	Frequency depends on the governing regulatory agency; some agencies recommend material blanks while others do not.
Temperature Blank	Blank is shipped only as required by individual laboratories	As provided by the laboratory or one small container with water.	
Field Duplicates	One field duplicate for every 20 investigative samples, or as required for project-specific goals.	Collect twice the standard sample volume.	Frequency depends on the governing regulatory agency; some agencies require one per 10 field duplicates.
Split Samples	Only collected as required by project-specific goals or as required by a regulatory agency.	Collect twice the standard sample volume	

Attachment 1 QC Sample Frequency			
Quality Control Sample	**Guidance for Collection Frequency**	**Volume Required**	**Comments on Collection Frequency**
Matrix Spike/Matrix Spike Duplicate Samples	If collected depending on project-specific goals, one MS and MSD for every 20 investigative samples.	Water — Collect three times the standard sample Soil — No extra volume is required, unless required by the laboratory.	Frequency depends on the governing regulatory agency; some agencies require one MS/MSD per sample shipment.
Background Samples	Only collected as required by project-specific goals.	Standard volume	

***Notes*:**
QA/QC sampling frequencies may or may not be relevant to each site. The project manager and/or sampling team must determine the applicable regulatory QC sampling requirements before developing QA/QC sampling plans.

Standard Operating Procedure No. FS-03
Groundwater Sampling

These standards will ensure continuity within the organization.

Preamble

This Standard Operating Procedure (SOP) represents EnSafe's minimum standard of practice. State and federal requirements may vary, as may project-specific work plans, all of which must be consulted before work begins. This SOP may be modified to meet specific regulatory-, client-, or project-specific criteria.

1.0 SCOPE AND APPLICABILITY

The procedures in this document are to be used by field personnel when collecting and handling groundwater samples in the field. Data obtained during groundwater sampling must be accurate, defensible, repeatable, and of the highest quality; therefore, it is critical that consistent and proper protocols are followed. This SOP is intended to ensure that collected groundwater samples will be representative of water in the aquifer or target formation and that the samples have not been altered or contaminated by the sampling or handling procedures.

On the occasion that field personnel determine that any of the procedures described are either inappropriate, inadequate, or impractical and that another procedure must be used to obtain a groundwater sample, the variant procedure will be documented in field logs, along with a description of the circumstances requiring its use. If used, alternative procedures must be approved by the project manager and be properly documented in the field logs.

The sampler must be aware of special equipment and precautions necessary when sampling groundwater for per- and polyfluoroalkyl substances (PFAS). SOP FS-12 **must** be used in conjunction with this SOP when sampling for PFAS and materials (e.g., Teflon) cited in this SOP (FS-03) **must** be substituted as directed in SOP FS-12.

1.1 Definitions

Chain-of-Custody — A process used to maintain and document the chronological and custody history of a sample.

PFAS — A family of complex synthetic chemicals containing fluorine and carbon atoms, which make them extremely persistent in the environment. PFAS were developed to make various products such as non-stick cookware, stain and water repellants, cleaning products, food packaging, paints, and firefighting foam.

Quality Assurance/Quality Control (QA/QC) — The term QA/QC is often used to refer to the actions performed for ensuring the quality of a product, service, or process.

Shall or *must* — When these words are associated with a procedure or other item, the item is mandatory, and performance is expected in all cases. Deviations from a procedure containing these words shall be documented.

Should or *may* — When these words are used, the referenced item is recommended or suggested, but not mandatory.

Standard Operating Procedure — A document that gives a step-by-step description of how a specific operation, method, or procedure is performed.

Volatile Organic Compound (VOC) — Any organic compound that evaporates readily to the atmosphere.

1.2 Related Standard Operating Procedures

The following are related EnSafe SOPs:

FC-01 Decontamination of Field Equipment
FD-01 Field Documentation
FQ-01 Quality Assurance/Quality Control Sampling
FS-12 Per- and Polyfluoroalkyl Substances Field Sampling Protocol
FT-02 Water Quality Parameter Testing

1.3 Health and Safety

Before commencing any groundwater sampling effort, field personnel shall review the health and safety requirements, any site-specific Health and Safety Plans, Job Safety Analysis, etc., to become familiar with the site hazards and safety requirements. Field personnel should make note of any known or potential hazards at the site, address chemicals that pose specific toxicity or safety concerns, and follow the relevant safety requirements.

Sampling activities may be performed by a single individual or with a group or team. Regardless of the number of individuals in a sampling team, each member of the team shall be comfortable with the tasks they are assigned. Comfort is loosely defined and includes not only items associated with the site-specific Health and Safety Plan or planning documents, but also a general awareness of the sample surroundings, including persons or wildlife in areas surrounding the site, quality of sample area (e.g., abandoned/vacant buildings, building condition, ground surface, heights, possible confined spaces), and weather conditions (e.g., extreme heat or cold and unexpected changes in weather). Wells that have not been sampled regularly may harbor ants, spiders, or wasps so caution should always be exercised when opening wells. If any individual is, or becomes, uncomfortable with the required sampling activities, then the sampling activities shall be reassessed.

Safety glasses with splash shields or goggles, disposable gloves, and steel-toe boots shall be worn during all groundwater sampling events, unless the site-specific Health and Safety Plan designates otherwise.

1.4 Cautions

The following precautions should be considered when collecting groundwater samples.

- Employees should be trained on the correct operation of sampling equipment and the correct operation and calibration of test equipment before proceeding with sampling. Improper use of sampling or test equipment could result in equipment damage or compromised sampling results.

- Know the well characteristics (i.e., well depth, depth to groundwater, volume of water to be evacuated) before sampling so that the appropriate pump and tubing is selected.

- Ensure the sample equipment is compatible (i.e., non-reactive, does not sorb or leach) with the analytes of concern.

- Special care to prevent sample contamination includes storing samples in a secure location to preclude conditions that could alter the sample properties. Samples shall be secured using custody seals during long-term storage or shipment.

- To minimize the potential for cross-contamination, always sample from the least contaminated location to the most contaminated location.

- Collected samples must remain in the custody of the sampler or sample custodian until the samples are relinquished to another party.

- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.

- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.

- Field sampling will be documented in field logs, which may be in the form of a logbook, field forms, or electronically. PFAS sampling will adhere to the material exceptions cited in SOP FS-12.

1.5 Interferences

Sampling methods and procedures shall not interfere with sample quality. The exact methods for sampling should be selected carefully depending on the depth of groundwater and construction of monitoring wells.

1.6 Personnel Qualifications

Personnel conducting groundwater sampling must be knowledgeable of the procedures in this SOP and related EnSafe SOPs. Training for each procedure will depend on the specific procedure. Field personnel are responsible for conducting groundwater sampling procedures according to this SOP and site-specific planning documents.

2.0 APPARATUS AND MATERIALS

Field personnel shall consult site-specific planning documents to determine the equipment requirements for the sampling procedures to be followed during the sampling effort. The specific apparatus and materials required will depend on the samples being collected.

The following equipment and materials may be needed to conduct the sampling procedures outlined in this SOP.

Purging and Sampling Equipment

- Pump (peristaltic, portable bladder, submersible)
- Polyethylene or Teflon bladders (for portable bladder pumps)
- Bladder pump controller (for portable bladder pumps)
- Air compressor (for portable bladder pumps)
- Nitrogen cylinders (for portable bladder pumps)
- 12-volt power source
- Polyethylene inlet and discharge tubing
- Silicone tubing appropriate for peristaltic pump head
- Teflon bailer appropriately sized for well
- Disposable bailer string (polypropylene)
- Multi-parameter water quality meter(s) with flow-through cell to measure temperature, pH, conductivity, dissolved oxygen (DO), and oxidation reduction potential (ORP)
- Turbidity meter
- Water level meter
- Oil/water interface probe

General Equipment

- Laboratory-supplied sampling containers
- Sample labels
- 5-gallon buckets
- Instrument calibration solutions
- Stopwatch or watch
- Disposable nitrile gloves
- Plastic zipper lock storage bags

Not all listed equipment may be necessary for a specific activity. Additional equipment may be required, depending on field conditions, requirements of the site-specific planning documents, or other planned sampling activities.

3.0 GROUNDWATER SAMPLING PROCEDURES

The following groundwater sampling procedures are based on currently accepted techniques. The specific sampling protocols to be followed at a site may vary from what is specified herein based on the requirements of a state environmental agency, the U.S. Environmental Protection Agency, client need/request, or site conditions and limitations. The site-specific planning documents should contain specific information on the sampling techniques, equipment, and protocols to be followed during sampling.

3.1 Special Sampling Considerations

Volatile Organic Compounds Analysis

Groundwater samples for VOC analysis must be collected in 40-milliliter (mL) glass vials with Teflon septa. The vial may either be pre-preserved with concentrated hydrochloric acid or unpreserved. Preserved samples have a 14-day holding time whereas unpreserved samples have a 7-day holding time. In most cases, the preserved vials are used to take advantage of the extended holding time. In some situations, however, it may be necessary to use the unpreserved vials. For example, if the groundwater has considerable dissolved limestone (i.e., is highly calcareous), there will likely be an effervescent reaction between the hydrochloric acid and the water that produces an abundance of fine bubbles and renders the sample unacceptable. In that case, unpreserved vials should be used.

If unpreserved vials are not available, the acid can be removed from the vial by flushing with the groundwater that is being sampled several times. The chain-of-custody form must reflect that the sample is unpreserved, and the laboratory should be notified via email, text, or phone to inform them to expect unpreserved samples with shorter holding times.

The samples should be collected with as little agitation or disturbance as possible. The vial should be filled so that there is a meniscus at the top of the vial and no bubbles or headspace should be present in the vial after it is capped. After the cap is securely tightened, the vial should be inverted and tapped on the palm or knuckle to check if any bubbles are dislodged. If a bubble or bubbles are present, the vial should be topped off using a minimal amount of sample to re-establish the meniscus during which care should be taken not to flush any preservative out of the vial. If bubbles are still present after topping off and capping the vial, a new vial should be obtained, and the sample re-collected. While the laboratory preparation method allows for bubbles up to 6 millimeters at the time of analysis, dissolved or entrained gases can coalesce during shipment. Collecting VOC vials absent of bubbles is generally feasible and a reasonable precaution.

Trace Contaminant Groundwater Sampling

- Sampling equipment must be constructed of Teflon or stainless-steel materials. Bailers and pumps should be of Teflon and stainless-steel construction throughout.

- New Teflon tubing should be used at each well, although tubing dedicated to a specific well may be reused, either after decontamination or storage in the well between sampling events.

- A clean pair of new non-powdered disposable gloves will be worn each time a different location is sampled, and the gloves should be donned immediately prior to sampling. The gloves should not contact the media being sampled and should be changed any time during sample collection if their cleanliness is compromised.

- Upon collection, individual sample containers (along with bubble wrap, if necessary) shall be placed in clean, disposable zipper-lock closure plastic bags for storage and/or shipment.

- Containers of samples suspected of containing high concentrations of contaminants shall be stored separately.

- Sampling should proceed from the least suspected contaminated area to the most suspected contaminated area if purging and sampling equipment are to be reused. Waste or highly contaminated samples must not be placed in the same cooler as samples (e.g., environmental or background) expected to contain lower contaminant levels.

- If possible, one member of the field sampling team should take all notes, collect photographs, and fill out labels, etc., while other members collect the samples.

- Clean plastic sheeting will be placed on the ground at each sample location to prevent or minimize contaminating sampling equipment by accidental contact with the ground surface.

- Samplers must use new, clean disposable, or non-disposable equipment cleaned according to procedures contained in Field Decontamination SOP FC-01.

3.2 Overview of Purging and Sampling Strategies

Purging is the process of removing stagnant water from a well, immediately before sampling, causing its replacement by groundwater from the adjacent formation that is representative of aquifer conditions. Sampling is the process of obtaining, containerizing, and preserving (when required) a groundwater sample after the purging process is complete. There are several approaches to well purging and sampling that may be appropriate in various circumstances or when using various combinations of available equipment. They are briefly summarized below and in Table 1 (Purge and Sample Strategies with Equipment Considerations).

The Multi-Volume Purge method involves removing a minimum of three well volumes of water from the top of the water column and then sampling when the well has achieved water quality parameter stability and adequately low turbidity. This is a traditional method and consistent results are generally obtainable by a variety of skilled personnel. A drawback is that large volumes of purge water may be produced for large diameter or deep wells.

The Low-Flow method involves purging the well at a relatively low flow rate that minimizes drawdown, with the pump or tubing inlet located within the screened interval of the well. The well is sampled when water quality parameters are stable, adequately low turbidity is achieved, and the water level has achieved a stable drawdown (an unchanging water level). This method is often faster than Multi-Volume Purge and generates less purge water, but the method requires more skill and judgment on the part of sampling personnel.

The Multi-Volume Purge and Low-Flow methods can be considered equivalent for conventionally screened and filter-packed wells in that they both sample a flow-weighted average of water entering the well during pumping. However, other variables can result in differences between results with the two methods. In repeat sampling events, the purging method should not change without appropriate cause and the change should be noted in the field logs.

Minimum-Purge and No-Purge methods assume that water within the screened interval of the well is at equilibrium with the water in the surrounding aquifer. This assumption should be carefully considered before using either of these methods and various cautions are discussed in sections below. The Minimum-Purge and No-Purge methods are most useful for long-term monitoring and are generally inappropriate for the early stages of investigation. In some cases, the methods might be used to gather screening-level data from wells that are too large to practically purge or have other sampling complications.

The Minimum-Purge and No-Purge methods collect water in the vicinity of the device under near-static conditions and are not equivalent to the Multi-Volume Purge and Low-Flow methods. Stratification of horizontal flow or vertical flow conditions within the well can result in non-intuitive and deceptive results. A comparison study should be conducted before transitioning a sampling program to the Minimum-Purge or No-Purge methods.

3.3 Purging

Wells are purged to eliminate stagnant water residing in the casing and/or screen that has undergone geochemical changes or loss of VOCs. At the conclusion of purging, the desired flow-weighted average of water entering the well under pumping conditions will be available for sampling. Turbidity is often elevated during purging by the disturbance of formation materials at the borehole walls.

Table 1
Purge and Sample Strategies with Equipment Considerations

Purging Strategy	Purge Eqpt	Sample Eqpt	Comments
Multi-Volume Purge	----------	----------	Overall Method Comments- Advantages: Consistent results can be achieved with minimal skill level required. Common, simple equipment can be used. Disadvantages: Can result in large volumes of purge water. Can take extended periods of time with large diameter wells or long water columns.
In this traditional method, 3-5 well volumes of water are removed from the top of the water column while verifying the stability of water quality parameters. Following the well purge, the well is sampled from the top of the water column.	Bailer	Bailer	Bailers are rarely used for purging due to the effort required, the difficulty of lowering turbidity adequately, and the possibility of aerating the upper water column.
	Electric Submersible Pump	Bailer	Common multiple-volume setup when depth to water exceeds 25 feet. Abbreviated pump decontamination procedure can be used between wells.
	Electric Submersible Pump	Electric Submersible Pump	Requires full pump decontamination and new tubing at each well. In most cases the pump would be deployed to the screened interval instead to perform Low-Flow sampling.
	Peristaltic Pump	Peristaltic Pump	Common, multi-volume setup when depth to water is less than 25 feet. Special sampling techniques are required for the collection of SVOCs and VOCs.
Low-Flow methods	----------	----------	Overall Method Comments- Advantages: Lower volumes of purge water. May be faster, especially with longer water columns. Disadvantages: Requires greater skill for consistent results. Higher tubing costs than multi-volume method.
The pump or tubing inlet is placed within the screened interval and the well is purged to stable water quality parameters while maintaining stable drawdown of the water level.	Electric Submersible Pump	Electric Submersible Pump	Commonly used when depth to water exceeds 25 feet. Pump is cleaned to sample equipment standards prior to sampling each well and new or dedicated tubing used for each well. Concerns have been raised concerning VOC loss from agitation in the turbine section or from sample heating.
	Peristaltic Pump	Peristaltic Pump	Commonly used where depth to water is less than 25 feet. Special sampling techniques required for the collection of SVOCs and VOCs. Concerns have been raised concerning VOC loss from vacuum created in sample tubing.
	Bladder Pump	Bladder Pump	Least danger of VOC loss as entire sample train is under positive pressure and little sample heating occurs. Difficult to remove large volumes of water in reasonable time. Mild surging effect may keep turbidity elevated in sensitive wells.
Minimum-Purge, No-Purge Methods	----------	----------	Overall Method Comments- Advantages: Very little or no waste water. Well suited to repeat sampling events. Likely faster with lower costs. Disadvantages: Not directly equivalent to other methods. Vertical stratification or vertical flow conditions in the screened interval can result in deceptive or non-intuitive analytical results.
Predicated on the assumption that aquifer flow through the well maintains the water in the screened interval in a state equivalent to that in the aquifer. This assumption should be proven or the data qualified. Sampling is conducted with little or no purge, or by equilibrating a sampler in screened interval.	Pumps, various	Pumps, various	In the minimum-purge method, the internal volume of the sample tubing and pump is calculated. One volume of the pump and tubing is purged to flush the equipment and the well is then sampled.
	na	Passive Diffusion Bags	In most common form, a sealed water-filled polyethylene bag is allowed to equilibrate in the water column. Suitable primarily for VOCs. Generally require 2 week minimum in-situ residence time.
	na	Hydrasleeves	Collect a fixed volume of water from a specific interval. Requires duplicate samplers or redeployment for larger volumes. Sorbtion issues may bias results.
	na	Snap sampler	Deploys a sample container in the sampling interval where it is allowed to equilibrate (commonly for two weeks) before being sealed insitu by the sampler mechanism and retrieved. Limited to specific containers.

As many contaminants (metals and organics) will sorb to the formation particles, a groundwater sample that includes particles will not represent the dissolved concentrations of the contaminants. Thus, a secondary goal of purging is to reduce the turbidity to the point that the sample will represent the dissolved concentration of contaminants.

In order to determine when a well has been adequately purged, sampling personnel should monitor, at a minimum, the pH, conductivity, DO, and turbidity of the groundwater removed, and the volume of water removed during purging. The following measurements should be recorded on the groundwater sampling form (see Attachment A) or in the field logbook: the start time of purging, the parameter measurements at intervals during purging, estimated pumped volumes, depths to water for Low-Flow purging, and any notes of unusual conditions. A typical table used for Low-Flow purging is reproduced below.

IN-SITU TESTING

Circle one: DEVELOPMENT / (SAMPLING)						☐ Bailer	☑ Pump
Time (hh:mm):	1605	1610	1615	1620	1625		
pH (units):	5.20	4.90	4.94	4.94	5.01		
Conductivity (mS/cm):	0.091	0.094	0.093	0.092	0.091		
Turbidity (NTU):	4.27	2.51	1.63	1.74	1.28		
DO (mg/L): Horiba	/	/	/	/	/		
YSI	6.10	6.27	6.39	6.45	6.38		
Temperature (C°):	17.36	17.47	16.39	16.95	16.51		
ORP (mV):	117.0	127.7	139.3	143.6	138.6		
Volume Purged (gal):	0.1	0.5	1.75	0.8	1.0		
Depth to Water (ft):	93.02	93.02	93.02	93.02	93.02		

3.4 Parameter Stabilization Criteria

With respect to the groundwater chemistry, an adequate purge is achieved when the pH and conductivity of groundwater have stabilized, and the turbidity has either stabilized or is below 20 Nephelometric Turbidity Units (NTUs).

Stabilization occurs when, for at least three consecutive measurements, the pH remains constant within 0.2 Standard Unit and conductivity varies no more than 5%. Other parameters, such as DO or ORP, may also be used as a purge adequacy parameter. Normal stability goals for DO are 0.2 mg/L or 10% change in saturation, whichever is greater; the common range for DO in groundwater is 0.0 to 3.0 mg/L. DO and ORP measurements must be conducted using either a flow-through cell or an over-topping cell to minimize oxygenation of the sample during measurement. A reasonable ORP stability goal is a range of 20 millivolts (mV) although ORP is rarely at equilibrium in environmental media and often will not demonstrate enough stability to be used as a purge stabilization parameter. A negative value indicates an anaerobic environment or reducing condition. For this reason, negative ORP readings should be associated with DO readings of less than 0.5 mg/L; with negative ORP readings, the water may exhibit a sulfur odor or gray color. Positive ORP readings should be associated with DO readings greater than 0.5 mg/L and lack of sulfur odors.

Determining the frequency of measurements has generally been left to Best Professional Judgement. Care is in order, as measurements recorded at frequent intervals with low flow rates can falsely indicate stability of parameters. Several measurements should be made early in the well purge to establish the direction and magnitude of trends, which can then inform the stability decision. Stability

parameters should either be not trending, or approaching an asymptote, when a stability determination is made. As a matter of practice, parameter measurements are generally made at 5- to 10-minute intervals.

Because the measured groundwater temperature during purging is subject to changes related to surface ambient conditions and pumping rates, its usefulness is limited for the purpose of determining parameter stability. Even though temperature is not used to determine stability, it is still advisable to record the temperature of purge water as it is often used in the interpretation of other parameters.

Most monitoring instruments require at least daily calibration in the field and shall be performed in accordance with the manufacturer's specifications. Special considerations and calibration related to water quality instruments are provided in SOP FT-02 Water Quality Parameter Testing.

3.5 Multi-Volume Purge

In the traditional Multi-Volume Purge method, water is removed from the top of the water column, causing water to enter the screen and flush stagnant casing water upward to be subsequently removed. When mixing fresh and stagnant water in the casing section, a minimum of three well volumes is removed, at which time purging can be terminated upon parameter stabilization. Wells can be assumed to be adequately purged when five well volumes have been removed, although further purging may be conducted to meet specific goals, such as further reduction of turbidity.

3.5.1 Purge Volume Determination

Prior to initiating the purge, the amount of water standing in the water column (water inside the well riser and screen) should be determined by measuring the diameter of the well, the water level, and the total depth of the well prior to inserting a pump or tubing into the well. The water level is subtracted from the total well depth, providing the length of the water column. Once this information is obtained, the volume of water to be purged can be determined using several methods, one of which is using the following equation:

$$V = 0.041\ d^2h$$

Where:
h = length of water column in feet
d = diameter of well in inches
V = one well volume in gallons

The field notes should reflect the single well volume calculations or determinations and a reference to the appropriate multiplication of that volume (i.e., a minimum three well volumes) clearly identified as an initial purge volume goal.

3.5.2 Pumping Conditions

The pump or tubing inlet should be located at the top of the water column. If the pump is placed deep into the water column, the water above the pump may not be removed and the subsequent samples, particularly if collected with a bailer, may not be representative of the aquifer conditions. If the recovery rate of the well is faster than the pump rate and no observable drawdown occurs, the pump should be raised until the intake is as close as possible to the top of the water column for the duration of purging. If the pump rate exceeds the recovery rate of the well, the pump or tubing will have to be lowered to accommodate the drawdown.

3.5.3 Stability of Chemical Parameters

In the Multi-Volume Purge method, a stability determination may be made after three well volumes have been removed. If the chemical parameters have not stabilized according to the above criteria, additional (up to a total of five) well volumes should be removed. If the parameters have not stabilized after the removal of five well volumes, it is at the discretion of the project manager whether or not to collect a sample or to continue purging. If, after five well volumes, pH, DO and conductivity have stabilized but the turbidity is decreasing and approaching an acceptable level, additional purging should be considered to obtain the best sample possible.

3.5.4 Sample Collection

There are several means by which sampling can proceed after adequate volume has been purged and water quality parameters have stabilized. If a submersible pump and tubing are of suitable material and cleanliness for sample collection, sampling can proceed immediately by directly filling bottles from the tubing outlet. With the Multi-Volume Purge method, the pump is commonly set up and cleaned in a manner suitable only for purging. In these cases, the pump is stopped and removed from the well and sampling proceeds with a bailer per the procedure described in Section 3.8.3. The pump should have a check valve to prevent water in the pump tubing from discharging back into the well when the pump is stopped. If a peristaltic pump is used, sampling can proceed as described in Section 3.8.1.

3.6 Low-Flow Method

This method involves placing the pump or tubing inlet within the screened interval of the well and purging at a low enough rate to achieve stable drawdown and minimal depression of the water level. The well is sampled without interruption after field parameters are stable and low turbidity is achieved. In general, only water in the screened interval of the well is pumped and the stagnant water in the well casing above the screen is not removed. Wells can generally be sampled in less time with less purge volume than with the Multi-Volume Purge method. More attention is required in the assessment of stability criteria than the Multi-Volume Purge method.

Low-flow purging does not require calculation of the water volume in the well, since purging is based solely on indicator parameter stabilization. Instead, the volume of the pump and discharge tubing are used to determine field measurement frequency and/or the minimum purge volume. Pump chamber or bladder volumes can be obtained from the manufacturer. Volumes of the sample tubing can be calculated or taken from Table 2.

Well casing volumes should still be calculated and recorded on the field logs in the event parameter stabilization is not achieved after a three-casing-volume purge.

Table 2
Equipment Volumes for Variable Tube Diameters
Discharge Tubing Volumes

Tubing Diameter (inches)	Volume per foot
1/2 OD and 3/8 ID	20 milliliter
3/8 OD and 1/4 ID	10 milliliter
1/4 OD and 1/8 ID	5 milliliter

Notes:
OD = outer diameter
ID = inner diameter

3.6.1 Placement of Pump Tubing or Intake

The inlet of the pump tubing or intake of the submersible pump is placed in the approximate mid-portion of the screened interval of the well. While it is often thought that particular aquifer zones can be targeted by specific pump or intake placement, for conventionally constructed screened and filter-packed monitoring wells, the zone monitored is only weakly dependent on the intake placement.[1]

The pump (or tubing) can be placed by carefully lowering it to the bottom of the well and then withdrawing half of the screen length, plus the length of any sump sections at the bottom of the well. A drawback of this approach is that it may stir up sediment at the well bottom. An alternate approach is to lower the pump or tubing a measured distance to place it at mid-screen without touching the bottom of the well. In the case of pumps, special care should be used by lowering it slowly, especially in the screened interval, to prevent elevating turbidity needlessly by the surging action of the pump.

3.6.2 Conditions of Pumping

Prior to initiating pumping, a properly decontaminated water level indicator should be lowered into the well to measure the water level prior to and during the purging process. Ideally, there should be only a slight and stable drawdown of the water column after pumping begins. In some cases, it will be necessary for the well to draw down a considerable distance (10 feet or more in extreme cases) to maintain a minimal usable pumping rate for sampling (100-200 mL per minute). Excessive pump rates and drawdown can result in increased turbidity or aeration of the sample if the screen is exposed. Stable drawdown is an essential condition of the Low-Flow method. If the stable drawdown condition cannot be met, then one of the other methods should be employed.

3.6.3 Stability of Chemical Parameters

As with the Multi-Volume Purging method described, it is important that all chemical parameters be stable prior to sampling. It is common for wells to require removal of one or more screened-interval volumes (approximately 2 gallons for a 10-foot screen in a 2-inch diameter well) to achieve stability. Although it is possible for wells to achieve stability with lower purge volumes, sampling personnel should exercise caution in making an premature stability determination.

3.6.4 Sample Collection

Low-Flow sampling is implemented using a pump and tubing suitable for sampling. After making the determination of parameter stability with stable drawdown, sampling can proceed immediately. When submersible or bladder pumps are used, sampling can proceed by directly filling bottles from the tubing outlet. When peristaltic pumps are used, sampling can proceed per the procedure described in Section 3.8.1.

3.7 Minimum-Purge and No-Purge Sampling

The Minimum-Purge and No-Purge sampling methods are employed when it is necessary to keep purge volumes to an absolute minimum, it is desirable to reduce long-term monitoring costs, or large wells or other limitations prevent well purging. The underlying assumption when employing these methods is that the water within the well screen is equilibrated with the groundwater in the associated formation. This assumption should be demonstrated prior to using these methods or the results suitably qualified. These methods are generally impractical to implement because of the lack of

[1] Varljen, M., Barcelona, M., Obereiner, J., & Kaminski, D. (2006). Numerical simulations to assess the monitoring zone achieved during Low-Flow purging and sampling. Ground Water Monitoring and Remediation, 26(1), 44-52.

hydrogeological information in early investigative phases and the necessity with some methods that the samplers be pre-deployed to allow equilibration.

Vertical flow conditions and stratification of the water column have also been known to result in deceptive and non-intuitive analytical results. The use of these methods in the early phases of investigation can result in misinterpretation of site conditions and plume boundaries.

Particular caution is in order in using these methods when any of the following conditions exist:

- Low hydraulic conductivity ($<10^{-5}$ centimeter/second)
- Low groundwater surface gradients
- Fractured bedrock
- Wells with long screened intervals
- Wells screened in materials of varying hydraulic conductivities

If it is desired to transition a long-term monitoring program to Minimum-Purge or No-Purge sampling, a pilot study should be conducted where the Minimum-Purge or No-Purge sample results are compared to the conventional methods in use. Multiple samplers may be deployed in the screened interval to help establish appropriate monitoring intervals.

These methods are in common use and for the purposes of the quality system they can be considered standard, but unaccredited, procedures. Several Minimum-Purge or No-Purge procedures that might be employed are shown below. It is not the intention to recommend particular equipment or vendors, and other equipment that can accomplish the same goals may be suitable.

3.7.1 Minimum-Purge Sampling

The pump or tubing inlet is deployed in the screened interval. A volume of water equal to the internal pump and tubing volume is pumped to flush the equipment. Sampling then proceeds immediately. While superficially similar to Low-Flow sampling, the results obtained using this method will be sensitive to the vertical pump or tubing inlet placement and are subject to the limitations described in Section 3.7.

3.7.2 Passive Diffusion Bags

The No-Purge Passive Diffusion Bag (PDB) typically consists of a sealed low-density polyethylene (LDPE) bag containing deionized water. The bag is deployed in the screened interval of a well and allowed to equilibrate, commonly for two weeks, prior to retrieval and decanting of the water into sample containers. Many VOCs will reach equilibrium across the LDPE material, including petroleum compounds and chlorinated solvents. Compounds showing poor equilibration across LDPE include acetone, methyl tertiary butyl ether, methyl isobutyl ketone, and styrene. PDBs have been constructed of other materials for sampling other analytes, but the vast majority of PDB samplers are of the LDPE material. For more information regarding PDB sampling and available vendors that sell PDBs, see SOP Diffusion Sampling FS-05.

3.7.3 HydraSleeves

HydraSleeves are No-Purge grab sampling devices consisting of a closed-bottom sleeve of low-density polyethylene with a reed valve at the top. They are deployed in a collapsed state to the desired interval and fill themselves through the reed valve when pulled upward through the sampling interval. The following is a summary of their operation.

- Sampler placement – A reusable weight is attached to the bottom of the sampler or the sampler is clipped to a weighted line. The HydraSleeve is lowered on the weighted line and placed with the top of the sampler at the bottom of the desired sampling interval. In-situ water pressure keeps the reed valve closed, preventing water from entering the sampler. The well is allowed to return to equilibrium.

- Sample collection – The reed valve opens to allow filling when the sampler is moved upward faster than 1 foot per second, either in one continuous upward pull or by cycling the sampler up and down to sample a shorter interval. There is no change in water level and only minimal agitation during collection.

- Sample retrieval – When the flexible sleeve is full, the reed valve closes, and the sampler can be recovered without entry of extraneous overlying fluids. Samples are removed by puncturing the sleeve with the pointed discharge tube and draining the contents into containers for sampling or field parameter measurements. Because the HydraSleeve is retrieved before equilibration can occur and is constructed of non-Teflon materials, there may be issues with sorption of contaminants when using this sampler.

3.7.4 Snap Samplers

The Snap Sampler is a patented No-Purge groundwater sampling device that employs a double-end-opening bottle with Snap-sealing end caps. The dedicated device is deployed at the desired position in the screened interval with up to six Snap Samplers and six individual sampling bottles. The device is allowed to equilibrate in the screened interval and retrieved between 3 and 14 days after deployment. Longer deployment times are possible to accommodate sampling schedules.

To operate, Snap Samplers are loaded with Snap Sampler bottles and the Snap caps are set in an open position. Samplers are deployed downhole with an attachment/trigger line and left to equilibrate. To collect samples, the Snap Sampler bottles seal under the water surface by pulling a mechanical trigger line or using an electric or pneumatic trigger system. The trigger releases Teflon Snap Caps that seal the double-ended bottles. The end caps are designed to seal the water sample within the bottles with no headspace vapor. After the closed vial is retrieved from the well, the bottles are prepared with standard septa screw caps and labeled for laboratory submittal. The manufacturer of the Snap Sampler provides considerable information on the validation and use of the device.

3.8 Equipment Considerations

Equipment choices are dictated by the purging and sampling method used, the depth to water, the quantity of water to be pumped, and quality considerations. The advantages and disadvantages of various commonly used pumps are discussed in the sections below and summarized in Table 1 (Purge and Sample Strategies with Equipment Considerations).

3.8.1 Use of Peristaltic Pumps

Peristaltic pumps are simple, inexpensive, and reliable equipment for purging and sampling where the limit of suction is not exceeded (approximately 25-30 vertical feet from the groundwater surface to the pump). When used for sampling, they should be equipped with new Teflon, or dedicated, tubing for each well. The flexible peristaltic pump-head tubing should also be changed between wells.

Samples for organic analyses generally should not be exposed to the flexible peristaltic pump-head tubing unless permitted in state-specific SOPs (e.g., Florida) due to the risk that the tubing would sorb contaminants and the propensity for this tubing to contribute organic compounds to the sample. Samples can be collected without contact with the pump-head tubing by using vacuum transfer caps for analyses requiring 1- to 4-liter glass containers/transfer bottles and the use of the soda-straw method for filling VOC vials.

The sample containers for more turbidity-sensitive analyses are filled first, as filling the VOC vials and, to a lesser extent, the glass bottles may disturb the well and increase turbidity. The most appropriate order of sampling with a peristaltic pump is to fill VOCs, semi-volatile organic compounds, pesticides, polychlorinated biphenyls, metals, cyanide, and wet chemistry parameters (chloride, sulfate, nitrate, nitrite, etc.).

The following step-by-step procedure assumes that the pump has been set up and that containers for a typical full suite of analyses will be filled. The procedure is suitable for use with Multi-Volume Purge and Low-Flow purge methods with minor differences in the collection of VOCs.

1. Deploy the lower end of the tubing to the desired point in the well (i.e., top-of-water for the Multi-Volume Purge method or the mid-screen for the Low-Flow method). Connect the well tubing to the flexible pump-head tubing and connect a short piece of tubing from the pump-head tubing to a measuring bucket.

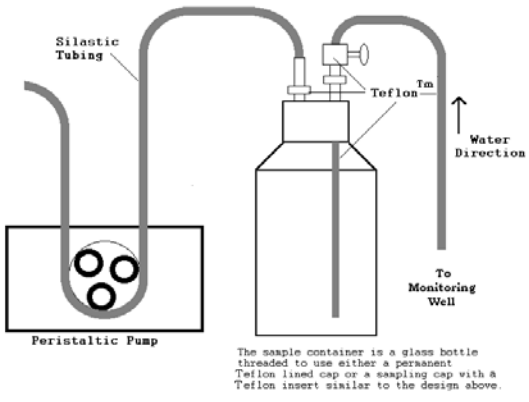
2. Turn on the pump and establish a suitable pumping rate. For the Multi-Volume Purge method, the rate will generally be sufficiently fast enough that the well can sustain without elevating turbidity. For the Low-Flow method, the pump rate is established at a slower rate to maintain a minimal and stable drawdown level.

3. Proceed with the measurement of water quality parameters and adjust the pump rate as needed to achieve low turbidity and stable drawdown.

4. When the well has been sufficiently purged, fill directly from the pump outlet containers for metals and any other contaminants except semi-volatile organic compounds. There is no need to interrupt pumping. The tubing should be held at the opening of the container and should not touch the container during filling. Protect caps from dust and debris during filling.

5. After filling the containers, stop the pump. Make sure that the tubing leading into the well is secured against movement during the following operations.

6. Create a crimp in the well tubing approximately 1 foot from the pump and grasp the crimped tubing in one hand. It is generally most effective to create a “double Z” crimp.



7. Cut the sample tubing between the crimp and the pump. The tightly held crimped tubing should keep water from running back into the well. In lieu of cutting the tubing, the well tubing can be disconnected from the pump and a short piece of tubing connected in its place.

8. Insert both free ends of the tubing into the ferrule-nut fittings of a pre-cleaned Teflon transfer cap assembly and tighten the nuts. Attach the transfer cap assembly to the first glass container for semi-volatile organic compound analysis and securely tighten the threaded ring.

9. Turn the pump on. Very slowly release the Z crimp in the sample tubing. As vacuum builds up in the sample container, water should begin to move up the sample tubing instead of back into the well. If after several minutes water has not moved up the tubing, check the tightness of fittings and the attachment of the cap to the bottle. Allowing water to rush back down the tubing from the Z crimp can surge the well and elevate turbidity.

10. Fill the container to about halfway between the shoulder and the neck. Crimp the well tubing. Move the transfer cap to any additional bottles and repeat the filling process.

11. When finished filling bottles with the transfer cap, again crimp the tubing. Remove the well tubing from the transfer cap and reattach it to the pump. Slowly run the pump and release the crimp until water is approaching the flexible peristaltic tubing.

12. Make a kink or otherwise mark the tubing at the top of the casing in case the tubing needs to be reinserted for additional sample volume. Slowly remove the tubing from the well and coil it in one hand in loose coils. With the top end of the tubing blocked, water is retained in the tubing as it is withdrawn, much as in a capped soda straw, hence the name for this method.

13. Remove the top from a 40-ml VOC vial and position the end of the sample tubing near the top of the vial. Reverse the pump direction and turn the speed knob to its slowest position. Turn on the pump and slowly increase speed until water slowly fills the vial. Fill the vial with a slow constant flow that does not agitate the water in the vial or entrain bubbles. Continue to fill the vial until a convex meniscus forms on the top of the vial and turn off the pump.
14. Carefully screw the septum-lid to the vial and fasten firmly. Invert the vial and tap on your knuckles to check for bubbles. Carefully add additional volume to the vial if necessary. Small bubbles are undesirable but may be unavoidable with some media, especially when using pre-preserved vials.

15. Repeat the filling process for additional vials. Avoid partially filling vials; if more volume is required than that contained in the tubing, purge the remaining water from the tubing and reinsert the tubing in the well to the level marked previously. Run the pump to refill the tubing. If performing Low-Flow sampling, run additional volume through the pump to purge any water that may have been collected from the stagnant water column.

16. Fill additional vials as needed. Be sure that any water that has contacted the flexible peristaltic tubing is not pumped into a vial.

3.8.2 Use of Submersible Centrifugal Pumps

Submersible centrifugal pumps are used in 2-inch diameter and larger wells. They are especially useful where large volumes of water are to be removed or when the groundwater surface is a large distance below ground surface. Commonly used pumps are the Grundfos Redi-Flo2, the Geotech GeoSub, and various Monsoon-style pumps. Other pumps are acceptable if constructed of suitable materials.

When used with the Multi-Volume Purge method, the pump is generally used only to purge, and sampling is performed using a bailer. In this use, the pump can be used with polyethylene or other tubing or hose that will not contribute contaminants to the well. The pump and tubing are decontaminated between wells per the relevant provisions of SOP Field Decontamination FC-01. When used in this application, the pump should be equipped with a check valve to prevent water in the discharge tubing or hose from running back down into the well.

When used for Low-Flow purging and sampling, the pump must be constructed of stainless-steel and Teflon. Pump cleaning at each well follows the more stringent procedures described in SOP Field Decontamination FC-01 for this application. The sample tubing should be either new Teflon tubing or tubing dedicated to each well. Dedicated tubing would ideally be cleaned between uses but tubing stored in the well casing between uses is acceptable, although caution should be exercised where very high concentrations of contaminants have been sampled in a well.

3.8.3 Use of Bailers

Bailers are a common means of sampling when the Multi-Volume Purge method is used. They are occasionally used for purging when other equipment is not available or has failed. As bailers surge the well on each withdrawal, it is difficult to lower turbidity adequately during a well purge. When used for sampling, bailers can elevate turbidity in a well before all sample volume is collected. If not lowered carefully into the top of the water column, the agitation may strip volatile compounds. Due to the difficulties and limitations inherent in their use, other sampling or purging means should generally be given preference over bailers.

Bailers should be closed-top Teflon bailers with Teflon-coated stainless-steel leaders used with new nylon haul rope. They are lowered gently into the top of the water column, allowed to fill, and removed slowly. It is critical that bailers be slowly and gently immersed into the top of the water column, particularly during final stages of purging and during sampling, to minimize turbidity and loss of volatile compounds.

If the well has previously been purged with a pump, there is likely stagnant water at the top of the well that was above the pump or tubing inlet. Several bailers of water should be retrieved and discarded to assure the upper stagnant water has been removed.

When sampling, containers are filled directly by pouring from the outlet at the top of the bailer. Containers for metals analysis should be filled first in case the bailing process increases well turbidity. VOC vials should be filled carefully and slowly with a constant flow to reduce agitation and stripping VOCs.

3.8.4 Use of Bladder Pumps

Bladder pumps use a source of compressed gas (i.e., commercial nitrogen in a tank or air compressor) to compress and release a bladder straddled by check valves within the pump body. As the bladder

is compressed, water is expelled out the upper check valve to the surface. When gas pressure is released, the bladder refills as well water enters the lower pump inlet. A control unit is used to control the pressure and timing of the bladder inflation gas flow.

Bladder pumps are capable of pumping groundwater from moderate depths (50-100 feet) but are not capable of high flow rates. As they operate cyclically, the well is surged slightly on each cycle and it may be difficult to lower turbidity in sensitive or poorly developed wells. As the entire sample train is under positive pressure and the pumps develop little heat, they are ideal for collecting samples for VOC analysis.

Prior to sampling and between each well the pumps shall be cleaned internally and externally per the provisions of SOP Field Decontamination FC-01 and a new Teflon bladder shall be installed. New (or dedicated) Teflon sample tubing will be used at each well. Polyethylene tubing is typically used for the compressed gas drive line and should also be new or dedicated tubing.

3.8.5 Use of Inertial Pumps

Inertial pumps consist of a check valve that is affixed to the lower end of semi-rigid tubing. The tubing and valve are cycled up and down, allowing water to alternately be drawn into the check valve inlet, then pulled up towards the surface. Two commonly used inertial pumps are the Waterra pump (for well diameters larger than 1 inch) and the Geoprobe Tubing Check Valve (for smaller-diameter wells). The primary use of these pumps is in well development where their near immunity to silt is an advantage. Inertial pumps should not be used for the final well purge or for sampling as there is a low likelihood of reducing turbidity to appropriate levels and they have the potential to strip volatiles from the water column through agitation.

To set up the pump, screw the check valve onto the discharge tubing where it will cut its own threads. In the case of the Waterra pump, a surge block can also be pressed onto the check valve. The pump is lowered into the well to the screened interval and rapidly cycled up and down a distance of 3 to 12 inches. The stroke length and speed can be adjusted for pumping effectiveness. Electric actuators can be used to reduce the effort involved. The pump should be moved to different levels in the screen to surge the entire screen. The pump can occasionally be lowered to the bottom of the well to pull out silt. Any silt that clogs the valve can be quickly rinsed out by the pump cycling; if the clog remains, the pump is easily retrieved and redeployed. The surging activity is usually continued until turbidity is lowered to a measurable range and cannot easily be lowered further. Further development or purging is then conducted with other pumps.

3.9 Wells with In-Place Plumbing and Pumps

Wells with in-place plumbing are commonly found at municipal water treatment plants, industrial water supplies, private residences, and other applications. Many permanent monitoring wells at active facilities are also equipped with dedicated in-place pumps.

A permanent monitoring well with an in-place pump may be treated as other monitoring wells without pumps. Since the in-place pump is generally hard-mounted at a pre-selected depth, it cannot be moved up or down during purging and sampling. If the pump inlet is above the screened interval, the well should be sampled using the Multi-Volume Purge method. If the pump intake is located within the screened interval, the well can be sampled using Low-Flow procedures. Known details of pump type and construction, tubing types, pump setting depths, and any other available information

about the system should be recorded in the field logbook and discussed with the project manager prior to sampling.

In the case of other types (e.g., municipal, industrial, and residential supply) of wells, there is typically not enough known about the construction aspects to apply the same criteria as used for monitoring wells. The volume to be purged in these situations therefore depends on several factors: whether the pumps are running continuously or intermittently and whether any storage/pressure tanks are located between the sampling point and the pump. The considerations and procedures to be followed when purging wells with in-place plumbing are discussed in Sections 3.9.1 and 3.9.2.

3.9.1 Continuously Running Pumps

If the pump runs more or less continuously, no purge (other than opening a valve and allowing it to flush for 3-5 minutes) is necessary. If a storage tank is present, a spigot, valve, or other sampling point should be found located between the pump and the storage tank. If no valve or spigot is present, locate and use the valve closest to the tank. Measurements of field parameters (if required) are recorded immediately prior to the time of sampling.

3.9.2 Intermittently or Infrequently Running Pumps

If the pump runs intermittently or infrequently, best judgment should be utilized to remove enough water from the plumbing to flush standing water from the piping and any storage tanks that might be present. Often under these conditions, 15 to 30 minutes of purging will be adequate. Measurements of pH, conductivity, temperature and turbidity should be made and recorded at intervals during the purge; the final measurements made at the time of sampling should be considered the measurements of record for the event.

3.10 Temporary Monitoring Wells

General Considerations

Because temporary wells are typically installed for immediate sample acquisition, the procedures used to purge temporary groundwater monitoring wells may differ from those for permanent wells. Temporary wells include standard well screen and riser placed in boreholes created by hand augering or drilling, or they may consist of a drive rod and screen such as a direct-push Geoprobe Screen Point that is driven into place at the desired sampling interval. As aquifer water enters the sampler immediately upon deployment, the requirement to remove several volumes of water to replace stagnant water does not necessarily apply. In practice, developing and purging the well to usable turbidity levels will remove many times the water that would be removed in a Multi-Volume Purge with calculated well volumes. It is important to note, however, that the longer a temporary well is in place and not sampled, the more stagnant the water column becomes and the more appropriate it becomes to apply standard permanent monitoring well purging criteria to achieve representative aquifer conditions in the sample.

Development of Temporary Wells

In cases where the temporary well is to be sampled immediately after installation, purging is conducted primarily to mitigate the impacts of installation. In most cases, temporary well installation procedures disturb the existing aquifer conditions, causing extreme turbidity. The goal of purging is to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure.

The following procedures have been found to be effective in developing and sampling small-diameter temporary wells where a peristaltic pump can be used. Turbidity can generally be lowered to 50 NTU at the time of sampling and turbidity less than 10 NTU is often achieved.

1. Cut peristaltic tubing long enough to reach the bottom of the well. Connect the tubing to a peristaltic pump and begin pumping at a high rate.
2. Use the tubing to vacuum out sediment at the bottom of the well.
3. Aggressively surge the end of the tubing in the screened interval by cycling the tubing rapidly up and down. Periodically repeat vacuuming of the well bottom.
4. When a visible break to a lower turbidity is observed, cease surging the well and begin lowering the pumping rate.
5. When the water clears (turbidity <100-200 NTU), begin raising the end of the tubing to the top of the water column.
6. Continue purging from the top of the water column, lowering the pump speed as necessary to achieve lower turbidity. When adequately low turbidity and stable water quality parameters have been achieved, sampling can proceed.

Where the water level is below the limit of suction in a small-diameter temporary well, a Geoprobe mechanical bladder pump can be used for purging and sampling. The well should first be developed with an inertial pump to remove the bulk of silt and suspended particles that could clog the check valves of the bladder pump. The inertial pump is used to vacuum out the bottom of the well and surged in the screened interval until a break to lower turbidity is observed prior to deployment of the bladder pump. Since the mechanical bladder pump requires cumbersome redeployment to change its pumping level, it should be deployed low enough in the water column that the water level will not be lowered below the pump during purging and sampling. The mechanical bladder pump is generally deployed above the screened interval to facilitate settling particles, but below the top of the water column to alleviate the need to reset the pump.

Other Considerations for Direct-Push Groundwater Sampling

With certain direct-push sampling techniques, such as the Hydropunch and other discrete samplers used with cone-penetrometer rigs, purging is either impractical or impossible. The sampling device is simply pushed or driven to the desired depth and opened, whereupon the sample is collected and retrieved. As a result, some samples collected in this way may not be satisfactory or acceptable for certain analyses because the sampler may collect a turbid sample inappropriate for metals analyses or the sample may have inadequate volume to achieve desired reporting levels.

3.11 Wells Purged to Dryness

In some situations, even with slow purge rates, a well may be purged dry using the Multi-Volume Purge method or stable drawdown cannot be maintained using the Low-Flow method. In these cases, the well should be purged to dryness (evacuated) and sampled upon recovery of adequate volume for sampling. Sampling should occur as soon as adequate volume has recovered. The field parameters should be measured and recorded at the time of sample collection as the measurements of record for the sampling event.

Sampling under these conditions is not ideal and suitable qualifications of the data should be included in the report. Water cascading down the screen into the well may strip volatile compounds and elevate turbidity. Although suffering from other limitations, No-Purge methods may prove useful for these wells.

3.12 Additional Purging and Sampling Considerations

Field Care of Purging Equipment

New plastic sheeting shall be placed on the ground surface around the well casing to prevent contamination of the pumps, hoses, ropes, etc., in the event they accidentally come into contact with the ground surface or, for some reason, they need to be placed on the ground during the purging event. Preferably, hoses used in purging that come into contact with groundwater be kept on a spool or contained in a large wash tub lined with plastic sheeting, both during transportation and during field use, to further minimize contamination by the transporting vehicle or the ground surface.

Careful consideration shall be given to using submersible centrifugal or bladder pumps to purge wells that are excessively contaminated with oily compounds as it may be difficult to adequately decontaminate severely contaminated pumps under field conditions. When wells of this type are encountered, alternative equipment such as bailers or peristaltic pumps should be considered.

Sample Preservation

After sample collection, all samples requiring preservation must be preserved as soon as practical. Consult with the laboratory for the correct preservative for the particular analytes of interest. All samples preserved using a pH adjustment (except VOCs) must be checked using pH strips to ensure that they were adequately preserved. This is done by pouring a small volume of sample over the strip; do not place the strip in the sample. Samples requiring reduced temperature storage should be placed on ice immediately.

3.13 Special Sample Collection Procedures

Order of Sampling with Respect to Analytes

In many situations when sampling permanent or temporary monitoring wells, sufficiently low turbidity is difficult to achieve and maintain. Removal and insertion of equipment after purging or during sampling may negate the low turbidities achieved during purging and elevate turbidity back to unacceptable levels. For this reason, it is important that special efforts be used to minimize any disturbance of the water column after purging and to fill sample containers for metals analysis first. The preferred order of sampling is metals, followed by other inorganic analytes, extractable organic compounds, then VOCs.

Filtering

As many contaminants are known to sorb to soil particles, the normal goal of sampling is to reduce the presence of these particles (measured by turbidity) in order that the dissolved concentration of contaminants can be obtained. However, transport of contaminants sorbed on colloidal particles can be a means of contaminant transport at some sites. For this reason, turbidity should be reduced through careful purging rather than through filtering samples so the colloidal particles would be included in the sample.

As a standard practice, groundwater samples will not be filtered for routine analysis. Filtering will usually only be performed to determine the fraction of major ions and trace metals passing the filter, used for flow system analysis, and for modeling geochemical speciation. Filtration is not acceptable

to correct for improperly designed or constructed monitoring wells, inadequate well development, inappropriate sampling methods, or poor sampling technique.

When samples are collected for routine analyses and are filtered, both filtered and non-filtered samples will be submitted for analyses. Samples for organic compounds analysis should not be filtered. Prior to filtration of the groundwater sample for any reason other than geochemical speciation modeling, the following criteria must be demonstrated to justify the use of filtered samples for inorganic analysis.

1. The monitoring wells, whether temporary or permanent, have been constructed and developed in accordance with the applicable SOP.

2. The groundwater samples were collected using sampling techniques in accordance with this section, and the groundwater samples were analyzed in accordance with this SOP.

3. Efforts have been undertaken to minimize any persistent sample turbidity problems. These efforts may consist of redevelopment or re-installation of permanent groundwater monitoring wells or implementation of carefully conducted low-flow rate sampling techniques.

If filtration is necessary for purposes of geochemical modeling or other purposes, the following procedures are suggested.

1. Accomplish in-line filtration by using disposable, high-capacity filter cartridges (barrel-type) or membrane filters in an in-line filter apparatus. The high-capacity barrel-type filter is preferred due to the higher surface area associated with this configuration. If a membrane filter is utilized, a minimum diameter of 142 millimeters is suggested.

2. When using pumps for sampling, the filter can generally be attached directly to the pump outlet. When sampling with a bailer or when otherwise required, an initial unfiltered sample with extra volume will be collected, and a peristaltic pump with filter used to decant and filter the sample to the final sample container.

3. Use a 0.45-micrometer (µm) pore-size filter to remove most non-dissolved particles. A 5-µm or 10-µm pore-size filter should be used for the purpose of determining colloidal constituent concentrations.

4. Fill the filter and rinse with approximately one additional filter volume prior to filling sample bottles.

Potential differences can result from variations in filtration procedures used to process water samples for the determination of trace element concentrations. A number of factors associated with filtration can substantially alter dissolved trace element concentrations including filter pore size, filter type, filter diameter, filtration method, volume of sample processed, suspended sediment concentration, suspended sediment grain-size distribution, concentration of colloids and colloidal-associated trace elements, and concentration of organic matter. Therefore, consistency is critical when comparing short-term and long-term results.

Bacterial Sampling

Whenever wells (normally potable wells) are sampled for bacteriological parameters, care must be taken to ensure the sterility of all sampling equipment and all other equipment entering the well.

4.0 DATA ACQUISITION, CALCULATIONS, AND DATA REDUCTION

Data is acquired in the field or office from the collection and analysis of samples. Other field data and observations are gathered and should be recorded in sampling notes and logs. Well volumes should be calculated per Section 3.5.1.

5.0 DATA/RECORDS MANAGEMENT

Information generated or obtained by field personnel will be organized and accounted for in accordance with established records management procedures found in SOP Field Documentation FD-01 or as specified in the project sampling and analysis plan. Field notes recorded in a bound field logbook will be generated, as well as chain-of-custody documentation and photographs, then stored in the project files.

6.0 QUALITY CONTROL AND QUALITY ASSURANCE

Quality assurance and quality control procedures shall adhere to requirements in project quality assurance plans, a sampling and analysis plan, and other planning documents.

7.0 NONCONFORMANCE AND CORRECTIVE ACTION

Nonconformance with this SOP may require corrective action as deemed necessary by the quality assurance manager or project manager. Notes, logs, and work will be reviewed periodically to ensure compliance.

8.0 REFERENCES

EnSafe Inc. *Corporate Health and Safety Plan*. March 2009. Memphis, Tennessee. March 2009.

EnSafe Inc. *Corporate Safety Management System*. Memphis, Tennessee. May 2014.

Resolution Consultants. *Monitoring Well Sampling, Procedure 3-14*, Revision 0. May 2012.

Varljen, M., Barcelona, M., Obereiner, J., & Kaminski, D. *Ground Water Monitoring and Remediation,* 26(1), 44-52. 2006.

U.S. Environmental Protection Agency, Region 4. *Groundwater Sampling. SESDPROC-301-R4*. Effective Date April 26, 2017. Retrieved from https://www.epa.gov/sites/production/files/2017-07/documents/groundwater_sampling301_af.r4.pdf.

Attachments — Forms, Checklists, and Data Sheets

Example Well Development and Groundwater Sampling Form

Author	Reviewer(s)	Revisions (Technical or Editorial)
Ben Brantley	Jason Broughton/Kate Freeman	Revision 0 — February 2020 (Initial Issue)
Dave Fuehrer	Holly Brauer	Revision 1 – May 2020 (Editorial)

Attachment A
Example Well Development and Groundwater Sampling Form

Attachment A: Example Groundwater Sampling Form

DATE:	**JOB NUMBER:**	**PHASE:**	**TASK:**
PROJECT:	**EVENT:**		
WELL ID:	**LOCATION:**		
WEATHER CONDITIONS:	**AMBIENT TEMP:**		
REVIEWED BY:	**PERSONNEL:**		

WELL DIA:	**WELL DEVELOPMENT**	
TOTAL DEPTH from TOC (ft.):	**START:**	**FINISH:**
DEPTH TO WATER from TOC (ft.):	**VOLUME PURGED (gal):**	
LENGTH OF WATER COL. (ft.):	**GROUNDWATER SAMPLING**	
1 VOLUME OF WATER (gal):	**START:**	**FINISH:**
3 VOLUMES OF WATER (gal):	**VOLUME PURGED (gal):**	
	ANALYSIS:	

MNA FIELD RESULTS

FERROUS IRON	**mg/L**	**CHLORIDE**	**mg/L**		**mg/L**
SULFIDE	**mg/L**	**ALKALINITY**	**mg/L**		**mg/L**
SULFATE	**mg/L**	**CO_2**	**mg/L**		**mg/L**

IN-SITU TESTING

Circle one:	**DEVELOPMENT**	**SAMPLING**				☐ **Bailer** ☐ **Pump**		**Description:**				
Time (hh:mm):												
pH (units):												
Conductivity (mS/cm):												
Turbidity (NTU):												
DO (mg/L):	**Horiba**											
	YSI											
Temperature (C°):												
ORP (mV):												
Volume Purged (gal):												
Depth to Water (ft):												
Orion ORP:	**mV**											
	E_H											
	Rel mV											
								Well Goes Dry While Purging ☐				

SAMPLE DATA ☐ **Bailer** ☐ **Pump** **Description:**

Sample ID	**Date (m/d/y)**	**Time (hh:mm)**	**Bottles (total to lab)**	**Filtered (0.45 µm)**	**Remarks**
Purging/Sampling Device Decon Process:					

COMMENTS:

Purge water placed in drum#_____ **Page** __ **of** __

Standard Operating Procedure
Water Quality Parameter Testing

These standards will ensure continuity within the organization.

Preamble

This standard operating procedure (SOP) is designed to provide the user procedures on how to collect water quality parameters. Before using this SOP and as part of the due diligence, the user is required to determine whether state and federal minimum parameter collection standards need to be met. If a difference exists between the SOPs herein and the state and/or federal SOPs, the state and federal SOPs takes precedent.

This SOP describes the activities and responsibilities pertaining to collecting water quality parameter data. Deviations from this SOP must be approved by the parties responsible for this task; i.e., Project Manager and/or Program Quality Manager.

1.0 SCOPE AND APPLICABILITY

This procedure provides guidance for expected sampling methods and protocols by all personnel related to the measurement of water quality parameters.

Field measurements of water quality parameters are commonly performed to evaluate surface water, groundwater, and drinking water. These tests are often performed to evaluate basic water quality parameters, to evaluate natural attenuation parameters, and to assess the presence of pore water entering a well.

As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by either the Project Manager (PM) or the Program Quality Manager and documented.

1.1 Definitions

Shall or *must* — When these words are associated with a procedure or other item, the item is mandatory, and performance is expected in all cases. Deviations from the SOP containing these words shall be documented.

Should or *may* — When these words are used, the referenced item is recommended or suggested, but not mandatory.

Barometric Pressure (BP) — The density of the atmosphere, which varies according to altitude and weather conditions.

Conductivity/Specific Conductance — A measure of the ability of water to pass electrical current, which increases with the amount of dissolved ionic substances (i.e., salts). The conductivity of water increases with increasing temperature.

Continuing Calibration Verification (CCV) — After use, the instrument or meter calibration is checked or verified by measuring a calibration standard of known value as if it were a sample and comparing

the measured result to the calibration acceptance criteria for the instrument/parameter.

Initial Calibration (IC) — Before use, the instrument or meter electronics are adjusted (manually or automatically) to a theoretical value (e.g., DO saturation) or a known value of a calibration standard. An IC is performed in preparation for the first use of an instrument or if a calibration verification does not meet acceptance criteria.

Initial Calibration Verification (ICV) — The instrument or meter calibration is checked or verified directly following IC by measuring a calibration standard of known value as if it were a sample and comparing the measured result to the calibration acceptance criteria for the instrument/parameter. If an ICV fails to meet acceptance criteria, immediately recalibrate the instrument using the applicable initial calibration procedure or remove it from service.

Total Dissolved Solids — A measure of the quantity of materials in water that are either dissolved or too small to be filtered.

Turbidity — Measure of the clarity of water in Nephelometric Turbidity Units (NTUs). Potable water typically has NTU values between 0.0 and 0.3 NTUs, depending on the state or regulatory program.

1.2 Related SOPs

FD-01-00 Field Documentation
FT-01-00 General Field Testing

1.3 Health and Safety

Health and safety considerations will vary according to the individual sampling sites and equipment used. Personnel shall review the site-specific Health and Safety Plan (HASP) to become familiar with the health and safety requirements, if available. Make note of any known or potential hazards listed in the HASP. Field personnel shall bring to the site any personal protective equipment outlined in the HASP or Sampling Plan appropriate for the hazards expected to be encountered during fieldwork activities. Every effort should be taken to minimize dermal contact with the water to be sampled and the standards used to calibrate equipment.

1.4 Cautions

Standards used to calibrate equipment should be used and stored in accordance with manufacturer's instructions. Additionally, standards cannot be used if the storage expiration dates have been exceeded.

Field personnel must ensure that all equipment is in proper working condition, calibrated, and that batteries are properly charged before using the equipment.

1.5 Interferences

During field testing, water quality data that is documented from field testing equipment may be influenced by certain outside factors that are unrelated to the actual site water quality. Such parameters and equipment include the following:

pH Meters

- pH probes must always be kept immersed in storage solution when not in use and calibrating a dry electrode will yields inaccurate readings. If a probe goes dry, hydrate it for 3-4 hours prior to calibration.

- Coatings of oils, greases, and particles may impair the electrode's response. Pat the electrode bulb dry with lint-free paper or cloth and rinse with de-ionized water. For cleaning hard-to-remove films, use isopropyl alcohol very sparingly so that the electronic surface is not damaged

- Poorly buffered solutions with low specific conductance (less than 200 microSiemens per centimeter [µS/cm]) may cause fluctuations in the pH readings. Equilibrate electrode by immersing in several aliquots of sample before taking pH.

Dissolved Oxygen

- Dissolved gases (e.g., hydrogen sulfide, halogens, sulfur dioxide) are a factor with the performance of DO probes. The effect is less pronounced on optical DO meters. Meter type and potential interferences should be considered based on potential sulfate/sulfide or nitrate/nitrite reducing environments.

- Exposure of the sample to the atmosphere will cause elevated DO measurements.

Turbidity Meter

If the weather is warm and humidity is high, condensation may collect on the cuvette. To avoid this, allow the sample to warm and dry the outside of the cuvette before making the measurement. One method used to accomplish this is to place the cuvette against one's body (armpits work well).

Temperature

Sample temperature will change rapidly when there are significant differences between the sample and ambient air.

1.6 Personnel Qualifications

Personnel preparing SOPs must be knowledgeable of the procedures in this SOP and other EnSafe SOPs. Training for each SOP will be dependent upon the specific procedure and each SOP will stipulate the type of training required for the procedure.

Field personnel are responsible for conducting water quality parameter testing procedures according to this SOP and the site-specific Sampling Plan. If, based on their best professional judgment, procedures to this SOP need to be modified in the field, the Field Manager or Project Manager will be notified of the deviations and the changes recorded in the field records. In addition, Field personnel should also be able to recognize problems with test equipment and have someone available for basic troubleshooting and repair.

2.0 APPARATUS AND MATERIALS

Field personnel shall consult the Work Plan and/or Sampling Plan to review the equipment requirements for the sampling procedures to be followed during the sampling effort. An example

Field form for documenting calibration and recording the parameter testing results can be found in Attachment 1.

Only indelible ink should be used when filling out the calibration and sampling logs.
The specific apparatus and materials required will depend on the water quality parameters being monitored. Table 1 shows the common equipment used in water quality parameter testing.

Table 1
Water Quality Parameter Testing — Common Equipment

Water Quality Parameter Instrument	Calibration Standards Required	Other Equipment
pH Meter	Yes — 3-Point Standards depending on sample range. Calibration must cover the range to be measured. If samples are above or below typical buffer standards (4, 7 and 10), special order buffers that fall outside sample pH range.	Container or flow thru cell for holding sample
Specific Conductance	Yes	Container or flow thru cell for holding sample
Oxidation-Reduction Potential Meter	Yes	Container or flow thru cell for holding sample
Turbidity Meter	Yes	Container or flow thru cell for holding sample
Dissolved Oxygen	No	Container or flow thru cell for holding sample
Thermometer	No	Container or flow thru cell for holding sample
Flow Rate	No	Calibrated Container

Field equipment are required to be decontaminated before, during (between samples), and after sampling events. Field personnel need to be familiar on how to operate the equipment and in a safe manner. If field personnel are unsure of the operating requirements the Field and/or Project Manager should be contacted for assistance. Make sure the proper sampling equipment is used for the task: if not the Field and/or Project Manager need to be informed.

3.0 PROCEDURES

3.1 Instrument or Method Calibration

Most monitoring instruments require calibration before use, and this calibration must be conducted in the field under the ambient climatic conditions that will be present during field sampling. Calibration of monitoring instruments shall be performed in accordance with the manufacturer's specifications and recorded in the in the field logs. Site-specific instrument calibration requirements should be specified in the Sampling Plan. The following minimum calibration requirements apply to the various types of meters used to gather water quality measurements.

3.1.1 Calibration Checks

Calibration checks are conducted by measuring a known standard. They must be completed after calibration and should be performed at least one other time (i.e., after lunch) and anytime suspect measurements are encountered. Table 2 provides general acceptance ranges to be used during calibration checks. If a meter is found to be outside of the acceptance range, the meter **must** be recalibrated. If the meter remains out of range, the project manager and/or the supplier of the meter should be contacted to determine alternative measures.

Table 2 Calibration Check Acceptance Limits	
Parameter	**Acceptance Criteria**
Dissolved Oxygen	±0.3 mg/L of the theoretical oxygen solubility
Oxidation-Reduction Potential	±10 mV from the theoretical standard value at that temperature
pH	±0.2 Standard pH Units
Specific Conductance	±5% of the standard
Turbidity	to 10 NTU: ±10% of the standard. 11 to 40 NTU: ±8% of the standard 41 to 100 NTU: ±6.5% of the standard

Notes:
mg/L = milligrams per liter
mV = millivolts
NTU = nephelometric turbidity units

3.1.2 pH Meters

- For the most accurate of pH measurements, pH meters should receive a three-point calibration. However, if a two-point calibration will bracket the sample pH of the site, a two-point calibration is acceptable. Three-point calibrations typically include calibrating to solutions of pH 7.00, 4.00, and 10.00. If sample pH is outside the calibration range of the solution standards, special buffers must be ordered to bracket the pH. Some meters will report the slope of the calibration and this may be used in checking the meter calibration (refer to the meter's manual). When performing an ICV, the result must be within ±0.2 pH units of the stated buffer value.

- pH meters should be calibrated across the range of values to be measured. The maximum and minimum calibration solutions shall be outside the range of anticipated values. For example, if the expected range is between 7.50 and 9.00, the 7.00 and the 10.00 standard should be used for calibration. Perform the IC using at least two buffers, and always use the pH 7.00 buffer first. A reading that is above the maximum (or below the minimum) calibration standard is an estimate only and is not valid. This condition requires obtaining a new standard that is above (or below) the reported value, depending on the measurement

- A percent slope of less than 90 percent indicates a bad electrode that must be changed or repaired. If percent slope cannot be determined, or the manufacturer's optimum specifications are different, follow the manufacturer's recommendation for maintaining optimum meter performance.

3.1.3 Specific Conductivity Meters

- For IC, when the sample measurements are expected to be 100 µS/cm or greater, use two standard potassium chloride (KCl) solutions that bracket the range of expected sample conductivities. Calibrate the instrument with the first standard. Verify the calibration of the instrument with the second standard, bracketing the range of expected sample values.

- If the instrument can be calibrated with more than one standard, choose additional calibration standards within the range of expected sample values.

- When the sample measurements are expected to be less than 100 µS/cm, based on previous measurements at the same site/location, a lower bracket is not required, but one standard

KCl solution that is within the range of expected measurements should be used for the IC and the ICV.

- Accept the calibration if the meter reads within ±5 percent of the value of any calibration standard used to verify the calibration.

- Most field instruments read conductivity directly. Record all readings and calculations in the calibration forms.

- For CCV, check the meter with at least one KCl standard with a specific conductance in the range of conductivity measured in environmental samples. The reading for the calibration verification must also be within ±5 percent of the standard value.

- If new environmental samples are encountered outside the range of the IC, verify the instrument calibration with two standards bracketing the range of sample values. If these calibration verifications fail, recalibrate the instrument.

3.1.4 Dissolved Oxygen Meters

- Before calibrating, check the probe membrane for bubbles, tears, or wrinkles. These conditions require replacement of the membrane in accordance with the manufacturer's directions.

- If the meter provides readings that are off-scale, will not calibrate, or drift, check the leads, contacts, etc., for corrosion and/or short circuits. These conditions require replacement maintenance in accordance with the manufacturer's directions.

- Most DO meters must be calibrated based on an environment of 100 percent humidity and a known elevation and BP. Place the probe in the calibration container with a moist towel and allow the probe to remain, undisturbed, for 10 to 20 minutes, this insures 100 percent humidity.

- The IC is an air calibration at 100% saturation. Before use, verify the meter calibration in water-saturated air to make sure it is properly calibrated and operating correctly. Make a similar verification at the end of the day or sampling event. Follow the manufacturer's instructions for your specific instrument. Allow an appropriate warm up period before IC. Wet the inside of the calibration chamber with water, pour out the excess water (leave a few drops), wipe any droplets off the membrane/sensor and insert the sensor into the chamber (this ensures 100 percent humidity). Allow adequate time for the DO sensor and the air inside the calibration chamber to equilibrate. Once the probe/calibration chamber is stable at ambient temperature, check the air temperature and determine, from the DO versus temperature table (see Attachment 2) what DO should measure. The acceptance criterion for DO ICV is ±0.3 milligrams per liter (mg/L).

- Use the same procedure as above for CCV.

3.1.5 Oxidation Reduction Potential (ORP) Meters

- Verify electrode response before use in the field.

- Equilibrate the standard solution to the temperature of the sample. The standard solution is based on a 25° Celsius (°C) temperature; however, the calibration solution standard's value will require adjustment based on the temperature.

- Immerse the electrodes and gently stir the standard solution in a beaker (or flow cell). Turn the meter on, placing the function switch in the millivolt (mV) mode.

- Let the electrode equilibrate and record the reading to the nearest millivolt. The reading must be within ±10 mV from the theoretical redox standard value at that temperature. If not, determine the problem and correct it before proceeding. Switch to temperature display and read the value.

- Record the mV reading and temperature in the field notebook or in form. Rinse the electrode with distilled water and proceed with the sample measurement, unless using a flow cell. If a flow cell is used, rinse between sample locations. After recording the measured value, add 200 mV and record the corrected value on the field sheet as well.

3.1.6 Turbidity Meters

- Perform an initial calibration using at least two primary standards.

- If the instrument cannot be calibrated with two standards, calibrate the instrument with one standard and verify with a second standard.

- Perform an ICV by reading at least one primary standard as a sample. The acceptance criterion for the ICV depends on the range of turbidity of the standard value:

  - Standard Value = 0.1 to 10 NTU: the response must be within 10 percent of the standard;

  - Standard Value = 11 to 40 NTU: the response must be within 8 percent of the standard;

  - Standard Value = 41 to 100 NTU: the response must be within 6.5 percent of the standard; and

  - Standard Value greater than 100 NTU: the response must be within 5 percent of the standard.

- Determining the Values of Secondary Standards — Use only those certified by the manufacturer for a specific instrument. Secondary standards may be used for CCVs. To initially determine the value of a secondary standard, assign the value that is determined immediately after an ICV or verification with primary standards. This is done by reading the secondary standard as a sample. This result must be within the manufacturer's stated tolerance range and ±10 percent of the assigned standard value. If the ±10 percent

criterion is not met, assign this reading as the value of the standard. If the reading is outside the manufacturer's stated tolerance range, discard the secondary standard.

- CCV — Perform a CCV using at least one primary or secondary standard. The calibration acceptance criteria are the same as those for an ICV.

3.2 Sample Collection

Samples will be collected using methods described in Work Plans and/or Sampling Plans. Equipment calibration and sample measurements will be performed as described in Sections 3.1 and 3.4; respectively. All calibration and sample measurement reading will be documented in a field log or sampling form.

3.3 Sample Handling and Preservation

Section 1.4 describes cautions regarding standard storage and expiration dates.

3.4 Sample Analysis

The following water quality parameter testing procedures are based on currently accepted techniques. The specific sampling protocols to be followed at a particular site may vary from what is specified herein based on the requirements of a state environmental agency, United States Environmental Protection Agency Region, client need/request, equipment, site conditions, and limitations. The Sampling Plan for a particular site should contain specific information on the sampling techniques, equipment, and protocols to be followed during sampling.

3.4.1 Direct Measurements

Direct measurements with meters are the most common methods and can be accomplished by placing a sample in a container with the probe or by allowing the water to flow past the probe in a flow cell. The use of a flow-through cell improves measurement quality by allowing the constant flow of water over the probes and reduces interaction of the sample with the atmosphere. Sample cups should be avoided, except for calibrating. The quantity of samples, timing, and methodology should be described in the project Sampling Plan.

Following calibration of required probes, connect the bottom flow-cell port to the discharge line of the pump. Connect the top port to a discharge line directed to a bucket to collect the purge water. Allow the flow cell to completely fill. As the water flows over the probe, record the measurements. Continue to record the measurements at regular intervals, as specified in the Sampling Plan.

When the ambient air temperatures are much higher or lower than the temperature of the water sample, it is best to keep the length of tubing between the wellhead and the flow cell as short as possible to prevent heating or cooling of the water. Tubing and flow-through cell should not be exposed to direct sunlight, particularly in the summer, if possible, to avoid heating of water samples.

3.4.2 Possible and Suspected Ranges

The concentration for each parameter range should be known so that concentrations outside of the range can be noted. Table 3 presents the maximum range of the parameter in sample. The table also presents the suspected range. Measurements outside of the maximum/minimum range should be considered in error and the measurement method should be checked. Concentrations outside the normal range should be treated as suspect but may be the result of contaminant

impact. For example, a pH of 2.0 would be out of the normally suspected range for sample but not at a site impacted with an acid.

Table 3
Minimum and Maximum Result Ranges

Parameter	Units	Possible Min	Possible Max	Normal Min	Normal Max	Notes
Dissolved Oxygen	mg/L	0.0	14.6 (0°C) 10.1 (15°C) 8.3 (2°C)	0.0	5	The colder the sample, the higher the DO reading. DO greater than 1 mg/L, ORP positive should not have sulfur odor, sulfide, ferrous iron, and/or gray color. DO less than 1 mg/L, ORP negative, may have sulfur odor, sulfide, ferrous iron, and/or gray color.
pH	SU	0	14	5	9	pH values exceeding 10 could indicate grout contamination
ORP	mV					DO greater than 1 mg/L, ORP positive should not have sulfur odor, sulfide, ferrous iron, and/or gray color. DO less than 1 mg/L, ORP negative, may have sulfur odor, sulfide, ferrous iron, and/or gray color.
Specific Conductance	µS/cm			varies	varies	
Temperature	°C	0	100	5	30	
Turbidity	NTU	0	Greater than 1,000	0	Greater than 1,000	50 NTU or greater suggests cloudiness.

Notes:

mg/L = milligrams per liter
°C = degrees Celsius
DO = dissolved oxygen
SU = standard units
ORP = oxidation reduction potential
mV = millivolts
mS/cm = microSiemens per centimeter
NTU = nephelometric turbidity units

4.0 DATA ACQUISITION, CALCULATIONS, AND DATA REDUCTION

Any observations made, or calculations/measurements performed in the field shall be documented in the field logs or on field forms.

4.1 Specific Conductivity Correction Factors

If the meter does not automatically correct for temperature (i.e., read Specific Conductivity) record Conductivity and adjust for temperature upon returning to the office. The following equation can be used to convert Conductivity to Specific Conductivity.

$$K = \frac{(Km)(C)}{1+0.0191(T-25)}$$

Where:

K	=	Conductivity in µmhos/cm at 25°C
Km	=	Measured conductivity in µmhos/cm at T degrees Celsius
C	=	Cell constant
T	=	Measured temperature of the sample in degrees Celsius

4.2 Percentage Difference Calculation

For evaluating slope of readings from either a flow cell or a sample cup.

$$\%\ Difference = \frac{(Highest\ Value - Lowest\ Value)}{Highest\ Value} \times 100$$

4.3 Convert Millimeters Mercury to Inches Mercury

To convert between millimeters of mercury (mmHg) and inches of mercury (inHg) use the formula below:

$$\text{mmHg} = \text{inHg x } 25.4$$

4.4 True Barometric Pressure

For converting BP obtained from a public domain source that is expressed in BP at sea level to BP at the subject site.

$$True\ BP = (BP) - \frac{(2.5\ \times Local\ Altitude)}{100}$$

Where: BP is in mmHg and Local Altitude is in feet

Example: BP at site A is 30.49 inHg and elevation is 544 feet, calculate True BP

Convert inHg to mmgHg:

$$\text{mmHg} = 30.49\ \text{inHg x } 25.4 = 774.4$$

mmHg Calculate True BP:

$$\text{TrueBP} = (774.4\ \text{mmHg}) - [2.5 * (544\ /100)] = 774.4\text{-}13.6 = 760.8\ \text{mmHg}$$

4.5 True Oxidation Reduction Potential or Eh

ORP readings may be converted Eh for metals evaluation, such as prediction of oxidation state and speciation. For converting measured ORP reported by the multimeter to Eh (which accounts for the difference between the field and reference electrode voltages), add 200 mV to the measured field value:

Corrected ORP = Field ORP + 200 mV
Do not forget to account for negative ORP values. (i.e. -75 mV + 200 mV = +125 mV)

5.0 DATA/RECORDS MANAGEMENT

Data will be recorded promptly, legibly, and in indelible ink on the appropriate field logs and forms. At the completion of a field effort, all field logs, field data forms, and calibration logs shall be scanned and made electronically available to the project team. The original field forms, calibrations logs, and field logs will be maintained in the project file.

6.0 QUALITY CONTROL AND QUALITY ASSURANCE

The Work Plan and Sampling Plan should specify the quality assurance/quality control procedures to be followed during the water quality parameter testing. Quality assurance/quality control can include self-checks such as calibrations of field monitoring instruments as described in earlier sections.

7.0 NONCONFORMANCE AND CORRECTIVE ACTION

Any deviations from the standard protocol, deviations from procedures specified in the Sampling Plan, or any problems that occur during procedure implementation must be documented in the field logs or on forms, and corrective action should be applied, if warranted. Alternatives to the procedures specified in the Sampling Plan may be acceptable if they conform to established field and sampling protocols. If used, alternative procedures must be approved by the Project Manager and be properly documented in the field logs and/or on forms.

8.0 REFERENCES

Florida Department of Environmental Protection, January 2017 Standard Operating Procedures available at: https://floridadep.gov/dear/quality-assurance/content/dep-sops

United States Environmental Protection Agency, Science and Ecosystem Support Division, Field Measurement Procedures available at: https://www.epa.gov/quality/quality-system-and-technical-procedures-sesd-field-branches

ATTACHMENTS — FORMS, CHECKLISTS, AND DATA SHEETS

Attachment 1 — Example Field Instrument Calibration Form
Attachment 2 — Solubility of Oxygen in Water at Atmospheric Pressure

Author	Reviewer	Revisions (Technical or Editorial)
Alan Jacobs	Tina Cantwell	Revision 0 – November 2016 (Initial Issue)
Tina Cantwell	Ben Brantley	Revision 1 – July 2019 (Editorial/Re-format/Add Attachments)

Attachment 1
Example Field Instrument Calibration Form

Field Instrument Calibration Form

Calibrated by: _____ **Equipment (Make/Model/Serial#):** _____

Date: _____ **Equipment (Make/Model/Serial#):** _____

pH (SU) — Standard: ± 0.2 standard units

	Initial Calibration		Initial Calibration Verification	
	Solution Lot	Reading	Solution Lot	Reading
pH7				
pH4				

Continuing Calibration Verification

	Reading	Deviation	Acceptable Variance (Y/N)
pH7			
pH4			

DO (mg/L) — Standard: ± 0.3 mg/L of theoretical

IC (Temp:) ICV (Temp:)

Saturation (%)	Reading (%)	Theoretical (mg/L)	Reading (mg/L)
100			

CCV (Temp:)

Saturation (%)	Reading (%)	Deviation	Acceptable Variance (Y/N)
100			

Theoretical (mg/L)	Reading (mg/L)	Deviation	Acceptable Variance (Y/N)

ORP (mV) — Standard: NA

IC Solution Lot: ICV Solution Lot:

TCS (Std/Temp)	Reading	TCS (Std/Temp)	Reading

CCV Solution Lot:

TCS (Std/Temp)	Reading	Deviation	Acceptable Variance (Y/N)

Turbidity (NTU) — Standard: ±10% of Standard

Initial Calibration

Standard	Reading

Continuing Calibration Verification

Standard	Reading	Deviation	Acceptable Variance (Y/N)

Conductivity (µS/cm) — Standard: ± 5% of standard value

IC Solution Lot: ICV Solution Lot:

Standard	Reading	Standard	Reading

CCV Solution Lot:

Standard	Reading	Deviation	Acceptable Variance (Y/N)

Comments:

Notes:

SL	solution lot	SU	standard units	NTU	Nephelometric Turbidity Units
TCS	temperature corrected standard	mV	millivolts	°C	degrees Celsius
Std	standard	%	percent	µS/cm	microsiemens per centimeter (temperature corrected)
Temp	temperature	mg/L	milligrams per liter		

Attachment 2
Solubility of Oxygen in Water at Atmospheric Pressure

Solubility of Oxygen in Water at Atmospheric Pressure	
Temperature (Degrees Celsius)	**Oxygen Solubility (Milligrams per Liter)**
0	14.621
1	14.216
2	13.829
3	13.46
4	13.107
5	12.77
6	12.447
7	12.139
8	11.843
9	11.559
10	11.288
11	11.027
12	10.777
13	10.537
14	10.306
15	10.084
16	9.87
17	9.665
18	9.467
19	9.276
20	9.092
21	8.915
22	8.743
23	8.578
24	8.418
25	8.263
26	8.113
27	7.968
28	7.827
29	7.691
30	7.559
31	7.43
32	7.305
33	7.183
34	7.065
35	9.65
36	6.837
37	6.727
38	6.62
39	6.515
40	6.412
41	6.312
42	6.213
43	6.116
44	6.021
45	5.927
46	8.835
47	5.744
48	5.654
49	5.565
50	5.477

Standard Operating Procedure
Manual Measurement of Water Levels in Wells

These standards will ensure continuity within the organization.

Preamble

This standard operating procedure (SOP) is designed to provide the user procedures on how to manually measure water levels in wells. Before using this SOP and as part of the due diligence, the user is required to determine whether state and federal water level collection standards need to be met. If a difference exists between the SOPs herein and the state and/or federal SOPs, the state and federal SOPs takes precedent. If this SOP is modified per agreement between parties associated with field activities, the agreed changes will become part of the SOP and the modifications will be appended to this SOP for the record.

This SOP describes the activities and responsibilities pertaining to collecting water levels in wells. If possible, or as soon as reasonably possible, deviations from this SOP must be approved by the parties responsible for this task; i.e., Project Manager and/or Program Quality Manager.

1.0 PURPOSE AND SCOPE

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when determining water levels in wells and total depths of wells.

1.2 Scope/Application

The procedures contained in this document are to be used by field investigators to measure water levels and depths of wells. On the occasion that field investigators determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that another procedure must be used for water level or depth determination, the variant procedure(s) will be documented in the field log book and the subsequent investigation report, along with a description of the circumstances requiring its use.

2.0 SAFETY

Proper safety precautions must be observed when measuring water levels in wells and determining their depths. Refer to the EnSafe Corporate Health and Safety Plan (HASP), the Project HASP, Job Hazard Analysis and SWAP for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Field investigators must address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

3.0 TERMS AND DEFINITIONS

None.

4.0 ROLES AND RESPONSIBILITIES

4.1 Project Manager

The Project Manager or project designee will be administratively responsible for ensuring water level measurements are carried out per this SOP. It is the project manager's responsibility to certify that the Site Specific Work Plan with this SOP has been read by all field personnel conducting the field activities, and that they understand all procedures contained therein. The project manager or designee will conduct periodic audits over the course of the project to make sure the Work Plan and these procedures are being followed.

4.2 Field Manager

The Field Manager is responsible for ensuring that all field personnel follow these procedures and that the water level measurement procedures are completed according to this SOP. As time permits, the Field Manager should conduct periodic inspections of the field techniques by field personnel.

Before field tasks begin and after field tasks are complete the Field Manager will inspect field equipment to make sure equipment is in working order and has been properly decontaminated.

The Field Manager will report any deviations from this SOP to the Project Manager or the Program Quality Control Manager, then document in the field logbook, and associated report or equivalent document.

4.3 Program Quality Manager

The program Quality Manager is responsible for ensuring overall compliance with this procedure and may request project audits to make sure procedures are being followed.

4.4 EnSafe Field Personnel

All field personnel must read and be familiar with this SOP. They are responsible for conducting water level measurement procedures according to this SOP and the Site Specific Work Plan. If, based on their best professional judgment, procedures in this SOP need to be modified in the field, the field manager will be notified of any deviations and the changes will be recorded in the field logbook. If the field manager cannot be contacted, then the project manager should be notified.

5.0 EQUIPMENT AND SUPPLIES

The following equipment is required for the collection of measurements:

- Electronic Water Level Indicator consisting of a spooled, two-wired electrical sounder or conductivity meter equipped with sufficient cable to reach the deepest water level. The cable should be graduated in 0.01-foot intervals.
- Weighted steel measuring tape.
- Extra batteries for meter (typically 9-volt).
- Decontamination supplies including a bucket, brush, soap or solvent cleaner depending upon contaminant, potable/deionized/distilled water, spray bottles, paper towel, and plastic sheeting.

- Keys for casing locks and tools needed to enter casings or flush-mounted well heads or vaults,
- Log book, well forms and pens
- Safety equipment and personal protective equipment (PPE).

6.0 WATER LEVEL AND DEPTH MEASUREMENT PROCEDURES

6.1 General

The measurement of the groundwater level in a well is frequently conducted in conjunction with ground water sampling to determine the "free" water surface. This potentiometric surface measurement can be used to establish ground water direction and gradients. Groundwater level and well depth measurements are needed to determine the volume of water or drawdown in the well casing for proper purging. All groundwater level and well depth measurements should be made relative to an established reference point on the well casing and should be documented in the field records. This reference point is usually identified by the well installer using a permanent marker for PVC wells, or by notching the top of casing with a chisel for stainless steel wells. By convention, this marking is usually placed on the north side of the top of casing. If no mark is apparent, the person performing the measurements should take both water level and depth measurements from the north side of the top of casing and note this procedure in the field logbook. To be useful for establishing groundwater gradient, the reference point should be tied in with the NGVD (National Geodetic Vertical Datum) or a local datum.

For an isolated group of wells, it is acceptable to use an arbitrary datum common to all wells in that group. Water levels should be allowed to equilibrate prior to measurement after removing sealing caps. There are no set guidelines and appropriate equilibration times can range from minutes to hours depending on well recharge, local geology and topography, and project objectives.

6.2 Procedural Precautions

The following precautions should be considered when measuring water levels and depths of wells:

- Special care must be taken to minimize the risk of cross-contamination between wells when conducting water level and depth measurements. This is accomplished primarily by:

1. Decontaminating the sounders or other measuring devices between wells according to the SOP for Field Equipment Cleaning and Decontamination

2. Maintaining the sounders in clean environment while in transit between wells

3. If known, measuring cleanest well locations first and then moving to more contaminated locations

- Water levels and well depths measured according to these procedures should be recorded in a bound logbook dedicated to the project consistent with the SOP for Logbooks.

- Serial numbers, property numbers or other unique identification for the water level indicator or sounder must also be recorded.

- If multiple field teams are used to collect measurements across a large site, then each team should measure the same well, sequentially, at the start of the event to ensure that consistent measurements are being obtained.

- If available, prior measurement event results should be obtained and reviewed by the field investigation team.

6.3 Specific Groundwater Level Measurement Techniques

Measuring the depth to the free ground water surface can be accomplished by the following methods. Method accuracies are noted for each of the specific methods described below.

- **Electronic Water Level Indicators** – These types of instruments consist of a spool of dual conductor wire, a probe attached to the end and an indicator. When the probe comes in contact with the water, the circuit is closed and a meter light and/or audible buzzer attached to the spool will signal contact. Penlight or 9-volt batteries are normally used as a power source (note: extra batteries should be available). Measurements should be made and recorded to the nearest 0.01 foot.

- **Other Methods** – There are other types of water level indicators and recorders available on the market, such as weighted steel tape, chalked tape, sliding float method, airline pressure method and automatic recording methods. These methods are primarily used for closed systems or permanent monitoring wells. Acoustic water level indicators are also available which measure water levels based on the measured return of an emitted acoustical impulse. Accuracies for these methods vary and should be evaluated with respect to project objectives before selection. Any method not capable of providing measurements to within 0.1 foot should not be used.

6.4 Sites with a Shallow Groundwater Gradient

Groundwater gradients at some sites can be very shallow and if gradient and groundwater flow pattern (gradient direction) determination are part of the project objectives, it is critical that groundwater level measurements obtained from wells are as accurate as possible. Special care should be taken to **allow the water level to equilibrate after removing sealing caps** and the same sounder/meter should be used for all measurements, if possible. The sounding activity should be coordinated to allow all wells to be sounded within the minimum possible time. This is particularly important in areas with potential tidal influences.

6.5 Total Well Depth Measurement Techniques

The well sounder, weighted tape or electronic water level indicators can be used to determine the total well depth. This is accomplished by lowering the tape or cable until the weighted end is felt resting on the bottom of the well. Because of tape buoyancy and weight effects encountered in deep wells with long water columns, it may be difficult to determine when the tape end is touching the bottom of the well and sediment in the bottom of the well can make it difficult to determine total depth. Care must be taken in these situations to ensure accurate measurements.

For total depth measurement, the operator may find it easier to allow the weight to touch bottom and then detect the 'tug' on the tape while lifting the weight off the well bottom.

All total depth measurements must be made and recorded to the nearest 0.1 foot.

As a cautionary note, when measuring well depths with the electronic water level indicators, the person performing the measurement must measure and add the length of the probe beneath the circuit closing electrodes to the depth measured to obtain the true depth. This is necessary because the tape distance markings are referenced to the electrodes, rather than the end of the probe.

7.0 ESTABLISHMENT OF TOP OF CASING ELEVATIONS

To establish groundwater surface elevations, the measured distance from the top of casing to the water surface is subtracted from the well top of casing (TOC) elevation. Obtaining accurate TOC elevations is crucial to developing an accurate groundwater surface elevation map and determination of groundwater flow direction. The only acceptable means of surveying well TOC elevations is differential leveling conducted to third order standards. This work must be conducted with an auto level as the leveling instrument. Surveying TOC elevations with a total station or survey-grade GPS will not provide the requisite accuracy. When adding wells to a monitoring network, it is permissible to tie the new well elevations to the known TOC elevations of existing wells in the network. The elevations of several wells in the existing network should be checked to assure that the relative differences in elevation match the recorded elevation data. Generally, the ground surface elevations at each well should be surveyed at the same time.

8.0 DOCUMENTATION / DATA / RECORDS MANAGEMENT

Data will be recorded promptly, legibly, and in indelible ink on the appropriate logbooks and forms. At the completion of a field effort, all logbooks, and field data forms shall be scanned and made electronically available to the project team. The original field forms, and logbook will be maintained in the project file.

9.0 QUALITY CONTROL

There are several specific quality control issues pertinent to conducting water level and depth measurements at wells. These are:

- Where possible devices used to measure groundwater levels should be verified annually against a National Institute of Standards and Technology (NIST) traceable measuring tape. These devices should check to within 0.01 feet per 10 feet of length with an allowable error of 0.03 feet in the first 30 feet. Before each use, these devices should be prepared according to the manufacturer's instructions (if appropriate) and checked for obvious damage.

- All verification and maintenance data should be documented electronically or recorded in a logbook maintained at the EnSafe Project Office.

- These devices should be decontaminated according to the procedures specified in the SOP for Sampling and Field Equipment Decontamination prior to use at the next well.

- Hydrocarbons (light non-aqueous phase liquids) in water require special sensors for accurate water levels.

10.0 NONCONFORMANCE AND CORRECTIVE ACTION

Deviations from the standard protocol, deviations from procedures specified in the Site Specific Work Plan, or any problems that occur during procedure implementation must be documented in the field logbook or on forms, and corrective action should be applied, if warranted. If alternative procedures are used, they must be approved by the Project Manager and be properly documented in the field logbook and/or on forms.

11.0 REFERENCES

The following references provide other useful information.

11.1 External References

ASTM D 4750-87. 1988. *Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well* (Observation Well).

United States Environmental Protection Agency. 1986. RCRA Groundwater Monitoring Technical Enforcement Document, OSWER-9950.1.

United States Environmental Protection Agency. Science and Ecosystem Support Division. 2013. Operating Procedure. *Groundwater Level and Well Depth Measurement*. SESDPROC-105-R2. Athens Georgia.

11.2 EnSafe Associated Standard Operating Procedures

- EnSafe Standard Operating Procedure (SOP) for Sampling and Field Equipment Decontamination
- EnSafe Standard Operating Procedure for Logbooks
- Project Health and Safety Plan, Job Hazard Analysis, Safe Work Assessment Permit (SWAP)